UNESCO-IHE
Institute for Water Education

Macro-economic Effects of Using the PowerCem Technology on Road Infrastructure in flood risk Areas

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PowerCem 2 7500x 3.0kV x7500 2μm

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Disclaimer

This document reflects the views of the individual researchers and has the approval of UNESCO-IHE and PowerCem Technologies B.V. The intellectual property of the study is owned by PowerCem Technologies B.V. The economic variables that are used in this study have been verified by a government body or an independent third party. The cost estimates for the technologies were received from contractors, and the positive effects of RoadCem technology were checked by the government of Tabasco State in Mexico (appendix 1). The aim of this study is to provide a model to assess the macro-economic effects of a new, proven technology, PowerCem, in answer to the need for durable infrastructure in flood-prone areas throughout the world.

Preface

The incidence of flooding is increasing in many areas around the world and ever more people are living in areas that are frequently flooded. The population increase in flood-prone areas is mainly due to the fact that a large part of economically significant activity is located near water.

The developed countries have invested large sums to decrease the risk of flooding in urban areas. The protection offered by high dikes, dams, canals, controlled inundation areas etc., effectively safeguards the urban areas and infrastructure behind them. These protection systems are so well trusted that the infrastructure behind them is no longer designed to withstand flooding. As a consequence, any flooding event could lead to large damage and a high cost burden on society. It is therefore necessary to check how our infrastructure can better cope with floods so as to minimize the burden of damage on society. Climate change is increasing the probability of floods, even despite the high investments in protection that were made in the past.

In countries with budget constraints and/or a greater probability of flooding, there is also a greater tendency to accept floods. In these cases coping measures for infrastructure have greater importance. And governments have to ensure that infrastructure is not damaged by floods, or only to a minor extent, in order to reduce the costs of recovery.

One of the most important failure mechanisms of relatively lower dikes, is erosion of the top, which not only destroys the water management system but could also lead to the destruction of the road network, as the top of the dike in many cases functions as a road. When floods occur, it is important that the road network remains intact as far as possible after a flood, so that help can be provided to the inundated area.

Acceptance of flooding and the creation of inundation areas, leads to a shift from protection measures towards coping measures, which in turn results in a need to adopt other technologies, such as PowerCem Technologies. Using this proven technology contributes to preventing damage to dikes from flooding. Traditional constructions have high direct damage costs, forcing the government to adopt a reactive policy rather than a pro-active one. **A pro-active policy, which is possible using PowerCem Technologies leads to a more reliable road network, especially just after a flooding, when the need for high availability of the road network is most urgent.**

We believe that this study is a worthwhile contribution for engineers, policy makers, contractors and the interested reader, allowing them to gain more insight into the macro-economic effects of the use of PowerCem Technologies in inundation areas.

Berry Gersonius PhD (UNESCO-IHE)
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Summary

This report offers a study of the macro-economic effects associated with the use of PowerCem-based Technology in flood prone and inundation areas. UNESCO-IHE is interested in creating a spread sheet risk model that can be used worldwide for new technologies, such as PowerCem Technologies, which supports a coping policy, thus facilitating a more pro-active policy. To create such a model it is important that it can be validated with exact figures. The validation of this model is based on the performance of the technology, which has been used widely and successfully in the state of Tabasco, Federal Republic of Mexico. Starting in 2008, the state's government decided to start working with a new nano-based technology, PowerCem Technology.
The state of Tabasco is a typical area that suffers from repeated large scale flooding. In some areas the roads are damaged several times every year. The floods occur due to the:

- region's low altitude;
- high rainfall intensities; and
- Conveyance of rainwater from the mountains in Chiapas to the Gulf of Mexico.

The region has suffered a number of from floods, with many casualties. On October 20th, 2011 the Tabasco region was declared a disaster area by president Calderon of Mexico[1].

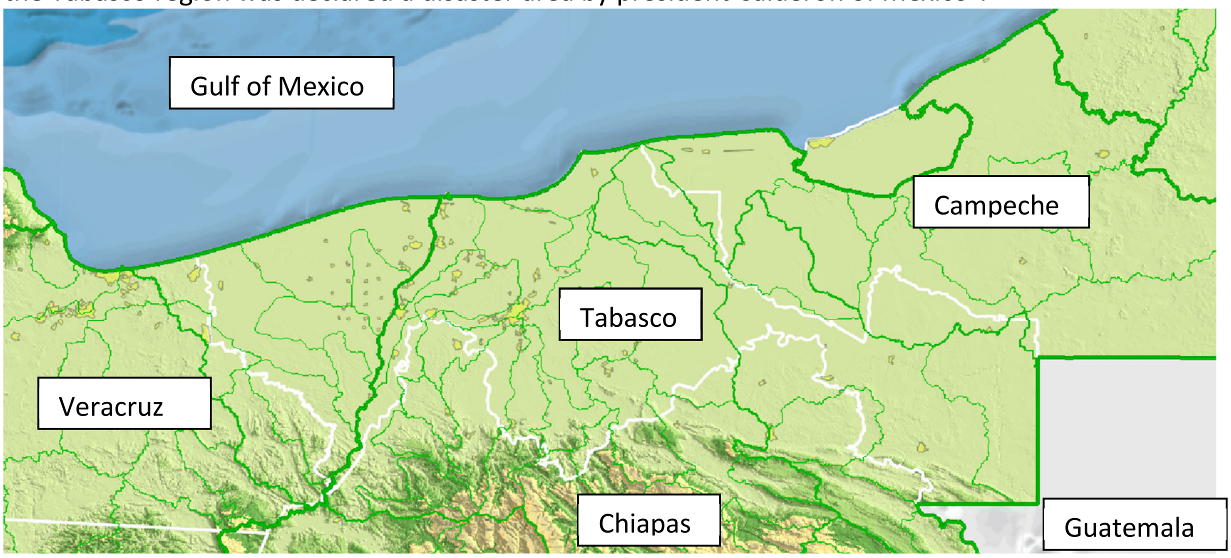

Figure 1: Location of Tabasco State.

Before, after and during a flood the road infrastructure is crucial for managing the transportation of persons, food and medical care. It is therefore required that the road infrastructure remains available as much as possible before, after and during such events.
In the past the pavement structure on top of the dikes was mainly built using traditional foundation materials. The problem with traditional, unbound materials is that they are vulnerable to erosion, whereas bound materials are liable to break up, due to erosion of the underlying layer.

[1] http://en.presidencia.gob.mx/2011/10/tabasco-declared-disaster-area-due-to-floods

PowerCem Technologies has been active in the region since 2008, where dikes and roads are being treated with RoadCem. By mixing this additive with cement and the in-situ soil, the dikes are protected against collapse and the road system is available for use, after a flood.

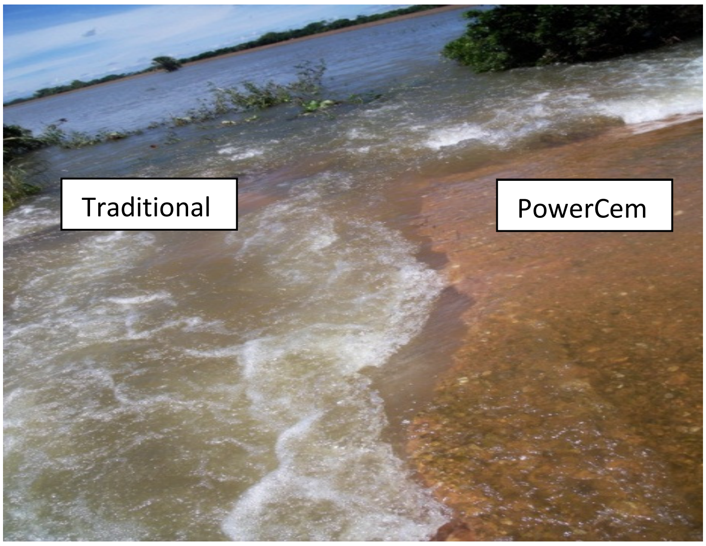

Figure 2: Difference in erosion between traditional pavement construction and RoadCem

This report offers a study of the direct macro-economic effects of the use of PowerCem-based technology. The variables that are used in the study have been verified by official government bodies, contractors and engineers.

It shows that the use of one of the products of PowerCem Technologies, RoadCem, prevents damage to the dike and state road infrastructure, with the implication of a significant reduction in direct damage costs coupled with lower indirect costs due to floods. The indirect costs are not taken into account in this model but the indirect costs will be described for specific areas.

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1 Introduction

1.1 Background

Recent decades have seen more and more floods and such floods are in many cases turning into disasters. The impact on the affected area or the whole country can be enormous. However there are several ways to prevent a flood or reduce its impact.

PowerCem Technologies is a company which offers a technology for infrastructure whereby a highly durable pavement construction will be achieved. Based on experiences, these pavement constructions are highly resistant against water erosion. This makes PowerCem Technology very useful in flood risk areas. The roads can be used directly after a flood to provide the region with food and medical supplies. Also the maintenance costs of the roads, after a flood will be reduced to a minimum.

In Tabasco, a State of Mexico, this technology has been used for 3 years now. During these years some floods occurred and PowerCem Technology based road constructions were not damaged. As such, many parties including governments, engineering companies and contractors are interested in this technology. The economic value of this technology will be emphasized with the aid of this study.

Figure 1.1: Road construction based on the PowerCem Technology

Figure 1.2: Traditional road construction

The parts of the road that were built with traditional construction methods were eroded and needed reconstruction. Some parts of the roads were constructed using the PowerCem technology and were not damaged.

1.2 Motive

To develop a risk based model a validation is required for the accuracy of the results. Therefore it was decided to focus the first model on the state Tabasco in Mexico. In this state floods occur almost every year. Also the PowerCem technology has already been used there on a widespread basis. So in this state there is sufficient information available to validate the model.
Although this model will be focused on a specific state, in the future it should be applicable for world-wide use.

The study begins with a pre calculation. On the basis of this pre calculation a research proposal is made. This research proposal has been approved by UNESCO-IHE and PowerCem Technologies. Following this pre calculation a quick scan is made on the basis of limited information. Finally a more detailed model is developed and validated. These results are given in this document. The procedure is presented in figure 1.1.

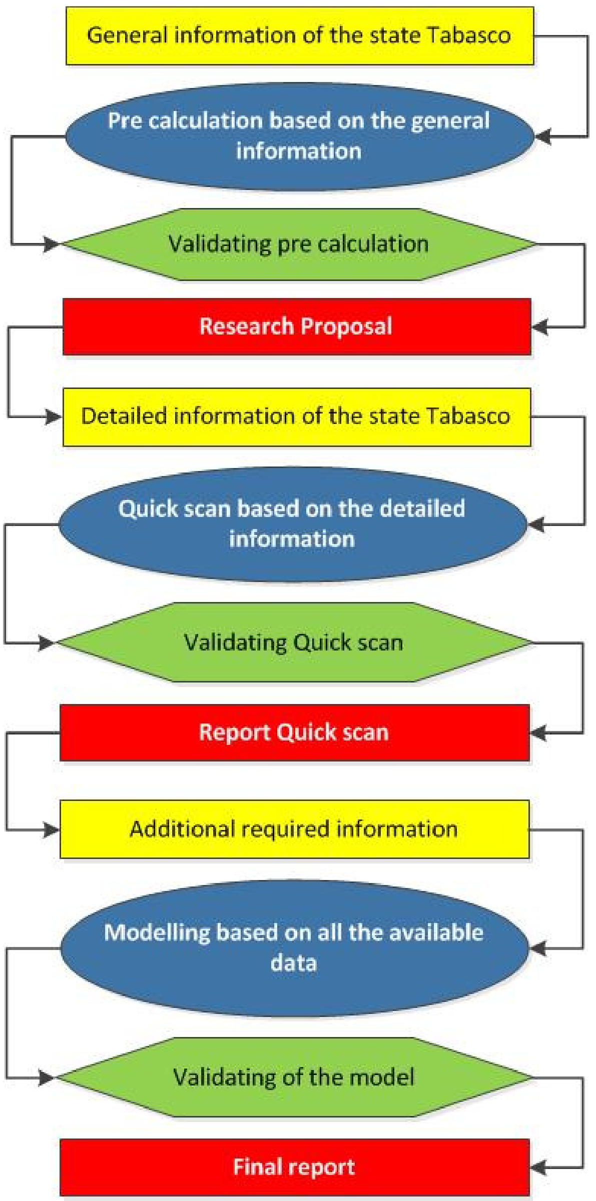

Figure 1.1: Research procedure

1.3 Objectives and scope of the study

The overall objective is to assess the economic effects of the PowerCem Technology on the infrastructure in flood risk and inundation areas. To determine the economic effects a difference is made in direct costs, e.g. the rehabilitation of a specific damaged road and the indirect costs, e.g. the influence on the accessibility of a region.

The direct economic effects are simulated in a model which is developed during this study. This study will be validated for a specific region; however the final model must be applicable for world-wide purposes. For the indirect costs the effects are described for three locations.

The main objective of this study will be answered by the following sub-objectives:

- What are the damages on the road infrastructure after a flood in a specific region?
- What are the damage and maintenance costs of traditional systems?
- What are the costs of the PowerCem Technology?
- What are the technical benefits of the PowerCem Technology in relation to traditional systems?

2 Research methodology

2.1 Study

The aim of the study is to develop a model wherein the economic effects of the PowerCem technology in flood risk areas will be shown. This risk based model has to be applicable for worldwide purposes. Since it is not realistic to validate such a model on the required scale, an inductive approach has been adopted. This means that this study will be focused on a smaller region with specific input data. Following the output of the model, the model will be validated with the actual values in that region to measure the accuracy of the model.

Such an approach has to be thought out securely up front to reach the aim with the required quality. The proposed approach is elaborated in this chapter using the following paragraphs:

- Scope.
- Input data.
- Verification.
- Model.
- Validation.

Figure 2.1 shows the workflow of the described approach.

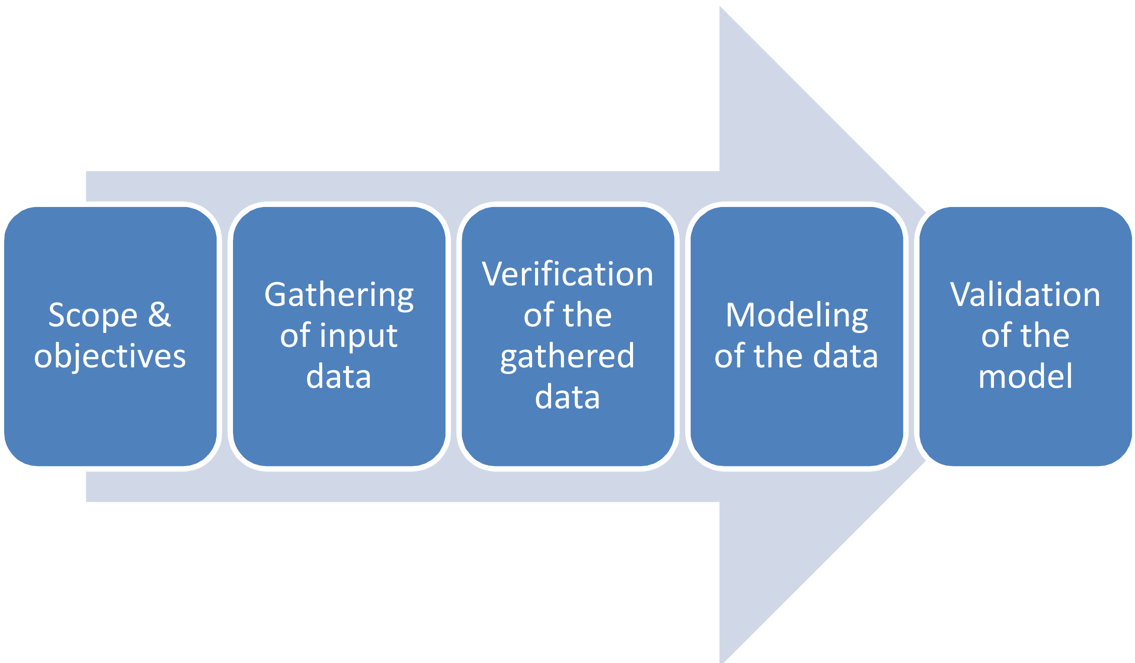

Figure 2.1: Workflow of the research methodology

2.2 Scope and objectives

To define the study the scope and objectives are explained in the following sub paragraphs:

- Spatial scale of the study.
- Objectives of the study.

Spatial scale:
The final model must be applicable for world-wide purposes; however this study will be focused on a specific region. The state of Tabasco in Mexico has been chosen, since there is a sufficient amount of data available from this region. This data will be used as input for the model as well as for the validation of the model.

Objectives:
The overall objective is to develop a model wherein the macro-economic effects of using the PowerCem Technology in flood risk areas can be calculated.

The main objective of this study is:
To investigate the macro-economic effects of the use of the PowerCem technology in flood risk areas.

The main objective will be answered by the following sub-objectives:

- What are the damages on the road infrastructure after a flood in a specific region?
- What is the damage and maintenance costs of traditional systems?
- What are the costs of the PowerCem Technology?
- What are the technical benefits of the PowerCem Technology in relation to traditional systems?

2.3 Input data

The input mainly determines the results of the model. A proper approach for the gathering, filtering and verification of the information is required.
In this research the required input information is inventoried. This paragraph describes the source of the input. The input data is divided in the following topics:

- Flood characteristics.
- Land use data.
- Constructions.
- Damage mechanisms.
- Maintenance strategy.
- Costs.

2.3.1 Flood characteristics

Since no detailed hydrologic data was available, floodplain delineation for this project was performed using actual flood records provided by the Dartmouth Flood Observatory (University of Colorado, 2012). Although the observatory maintains global flood records from 1985-present, detailed GIS data showing the flood extent for the Tabasco region is available since June 28th 2011. Using the LANCE_MODIS (NASA, 2012) rapid response processor in combination with a noise cancelling water pixel identification algorithm (Brakenridge, 2011), daily flood records are available at a spatial resolution of about 250m. Note that the data only provides the observed flood extent; the geographic distribution of the associated inundation depths was not available. GIS data on street networks have been derived from the Open Streetmap Project (Open StreetMap, 2012) in combination with manual tracking based on Google Maps imagery.

The identification of flooded roads consisted of the following steps:

1. *Flood extent delineation*. Union of 314 daily flood extents over the period June 28th 2011 – May 7th 2012;
2. *Soil type identification*. Preparation of base maps identifying the different top layer soil types with the region;
3. *Road segment identification*. Preparation of a road map using a classification of 5 individual road types;
4. *Road segment intersection*. Intersecting the street network with the delineated flood extent and soil types to obtain base statistics about length of inundated road segments;
5. *Applying administrative boundaries*. Clipping the GIS-data by applying the administrative boundaries of the Tabasco province.
6. *Preparation of Base statistics*. Calculation of inundated road segments per soil type and road type.

Apart from providing the observed flood extent over a longer period, the daily flood records also provide information about the inundation frequency of individual areas (i.e. the aggregate amount of days an individual area is flooded).

A disadvantage of the combined daily flood records and the delineated flood extent provide information about geographic distribution and frequency of inundated areas within the last 10 months is that the results cannot be generalized to longer periods. No data is available about the exceeding probability of the individual events, therefore it is unknown if the calculated extent and frequency is representative within the Tabasco region. Furthermore, since no inundation depths are provided, the actual impact level of the consequences is uncertain; lower and higher inundation levels are treated similarly in relation to the consequences of any inundated road network.

2.3.2 Land use data

The land use data covers all the valuable data regarding the soils, traffic information and other important parameters which have an influence on the economic effects of different road systems.
This data is divided in the following topics:

- Soil types.
- Altitude in the region.
- Road infrastructure.

Soil types

A lot of regions will have a rich variation of soil types with a wide variation in specific parameters. This is also the case for the Tabasco region. The soil types in the region will be reclassified to conform to a system which is suitable for macro-economic effects.
Therefore the parameters of the soil which are influential are determined. The important parameters are summarized as follows;

- The bearing capacity.
- The chemical properties.
- Grain distribution.
- Liquid limit.

Bearing capacity

The bearing capacity of the soil is important in determining the pavement thickness of a traditional construction as well a construction using PowerCem technology.

Chemical properties

The chemical properties of a soil have an influence on the mix composition of a PowerCem construction. The amount of organic matter is important when determining the dosage of RoadCem and cement.

Grain size distribution

The grain size distribution is one method to check the type of a soil. There are a several classification systems which use the grain size distribution classification of a soil. In this research the USCS systematic will be used. Using the USCS systematic the soil types will be classified in four main classes.

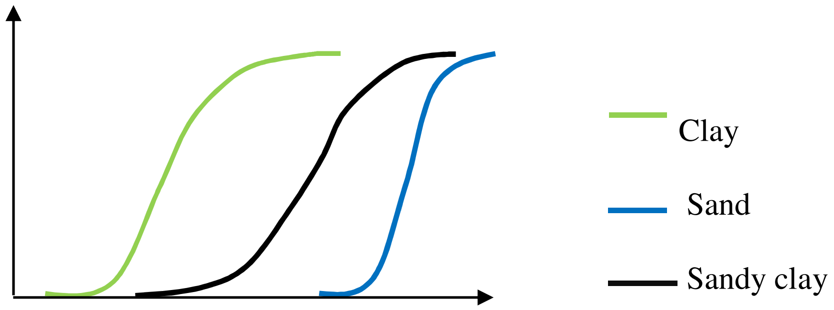

Figure 2.2: Grain size distribution of different soil types

Using the USCS classification system and a pre study of the occurring soils, four main classes are determined as follows:

- Soil type 1: Organic clays.
- Soil type 2: Clays.
- Soil type 3: Sandy clays.
- Soil type 4: Sand.

There are maps which show the soil types available in the region. These soil types have to be classified into the four main classes.

Road infrastructure

The SCT use a classification system for the Road infrastructure in Mexico. In this classification, the roads are divided into five classes:

- Road type 1: Highways.
- Road type 2: Primary roads.
- Road type 3: Secondary roads.
- Road type 4: Rural roads.
- Road type 5: Access roads.

The Road types are determined on the basis of the expected traffic intensity. For this study the same classification system is used.

The road infrastructure is partly available via open street maps. The missing roads are drawn manually using an underlay of Google Earth.

Part of the road infrastructure has already been constructed using the PowerCem Technology. To validate the final model and to get an impression of the benefits of the PowerCem Technology these roads have to be specified. The information regarding the PowerCem based roads is provided by PowerCem Mexico.

2.3.3 Constructions

For this study standard constructions are used, based on practice. The standards for traditional constructions are given by the SCT. These constructions are calculated by PowerCem technologies as described in this paragraph. With this information the standards for RoadCem based construction are designed.
Therefore, for all road and soil types, 2 constructions are designed:

- 1 traditional construction.
- 1 RoadCem construction.

Calculation methodology:
The constructions are calculated using an iterative process. Construction is assumed on the basis of previous experiences. The construction will be checked on possible failure mechanisms. To optimize the chosen construction, the following variables can be changed:

- Types of materials used.
- Physical parameters of the materials.
- Dimensions of the layers.

The calculation steps are summarized below.

Step 1: Determination of loading
First the expected loads on the road have to be assumed. For this study these values depend on the road type. A distinction is made for the heaviest load which can occur, and the standard repeating loads. This information is defined by the SCT.

Step 2: Determination of stresses and strains
Using the computer program BISAR the strains and stresses in the construction will be determined. BISAR is a linear elastic calculation program which uses the stiffness and viscosity of the materials to calculate the stresses and strains on the most critical points of the pavement construction.

Step 3: Control of the maximum stresses and strains
In step 1 the stresses and strains are calculated on the critical points. These strains and stresses have to be checked with the parameters of the material, i.e. Is the material able to absorb the stresses and strains? For most materials these properties are made available by the supplier.

Step 4: Fatigue properties
The most common failure mechanism of a road construction is the result of repeating loads, in general the passing of trucks. There is a significant difference in this failure mechanism, comparing a RoadCem pavement construction and a traditional construction.
For a traditional construction, there are 2 standard failure mechanisms:

1. Repeating strain in the bottom of the asphalt layer will lead to crack's. These cracks will reflect to the surface. The quality of the road will be significantly reduced and structural maintenance will be required.
2. In a pavement construction with a limited depth of asphalt, there will be permanent deformations in the unbound layers below. The deformations will reflect on the surface with crack's appearing which will require structural maintenance

Both of these scenarios have to be checked.

The standard failure mechanisms for a construction based on PowerCem technology is the repeating strain in the bottom of the RoadCem-cement layer. When cracks occur in the bottom of the RoadCem-cement layer the road is deemed structurally damaged.

2.3.4 Damage mechanisms

To determine the amount of damaged roads in a flooded area, a local flood pattern must be examined. The percentage of actual damaged roads in a specific flooded area must be determined; a distinction will be made for:

- Type of road.
- The scale of the damage.
- The seriousness of the damage.

The seriousness of damage will be classified into three damage classes:

1. **Totally destroyed road**
   Result of erosion
2. **Many cracks and holes**
   Result of erosion and/or weakening of the (sub) base course by saturation
3. **Incidental damaged parts**
   Result of erosion and/or weakening of the (sub) base course by saturation

The percentage of actual damaged roads versus the total flooded roads in this local area will be standard for the flooded roads in the whole state.

2.3.5 Maintenance policy

Depending of the damage of the road, measures will be taken. These measures depend on the seriousness and the scale of the damage. In table 1.1 the traditional measures for a traditional approach are compared with a total reconstruction using the PowerCem technology.

Damage type	Traditional measure	PowerCem measure
1	Total reconstruction on the traditional way	Total reconstruction using the PowerCem technology
2	Reparation of damaged parts, like: - Replacement of the top layer - Filling op gaps	Total reconstruction using the PowerCem technology, on damaged parts. This is a durable structural measure.
3	Reparation of damaged parts, like: - Filling up gaps - Closing of cracks	Total reconstruction using the PowerCem technology, on damaged parts. This is a durable structural measure.

Table 2.1: Measure for several damage types.

2.3.6 Costs

This study will focus on direct costs; therefore the following cost specifications are required:

- Construction costs for different road constructions.
- Construction costs of the road constructions on the basis of the use of the PowerCem technology.
- Damage costs.
- Maintenance costs.

These costs will be calculated in collaboration with PowerCem Mexico using reference projects in the state Tabasco.

The indirect costs are expected to be high and will have an enormous influence on the macro-economic effects. When a road is damaged such that it has to be closed, the impact on the population or industry can be high. Due to the limited timeframe of this study, these costs are not included in the model. The available information, though, will be used to give an impression of the expected indirect costs and will be used for recommendations for further research.

2.4 Verification

The input data of a model must be verified. The input data is the foundation for the output that will come from that model. The input data must be verified by several parties. Also, the sensitivity of a variation in the input data on the total model must be verified. Certain input data has a major influence on the final results, and this input data must be verified with careful attention. The input data is verified by SCT, PowerCem Mexico, PowerCem Technologies and the contractors.

2.5 Validation

After the input data is verified and the output is known, relations will be laid between the input variables and the output. The validation is split into three procedures:

1. The input variables, must lead to a model output that will conform to the actual results.
2. If other input variables are used for another region, the output of the model must also lead to output that is correct for this other region.
3. By changing the input with high variations, the output of the model must also indicate that this results in high variations in the output.

3 Input model

3.1 General

In this chapter the data used, is depicted in the following paragraphs:

- Flood characteristics.
- Land use data.
- Constructions.
- Damage mechanisms.
- Maintenance policy.
- Costs.

3.2 Flood characteristics

Using the flood data of 28-06-2011 until 07-05-2012, the extents of roads flooded are located in figure 3.1 below.

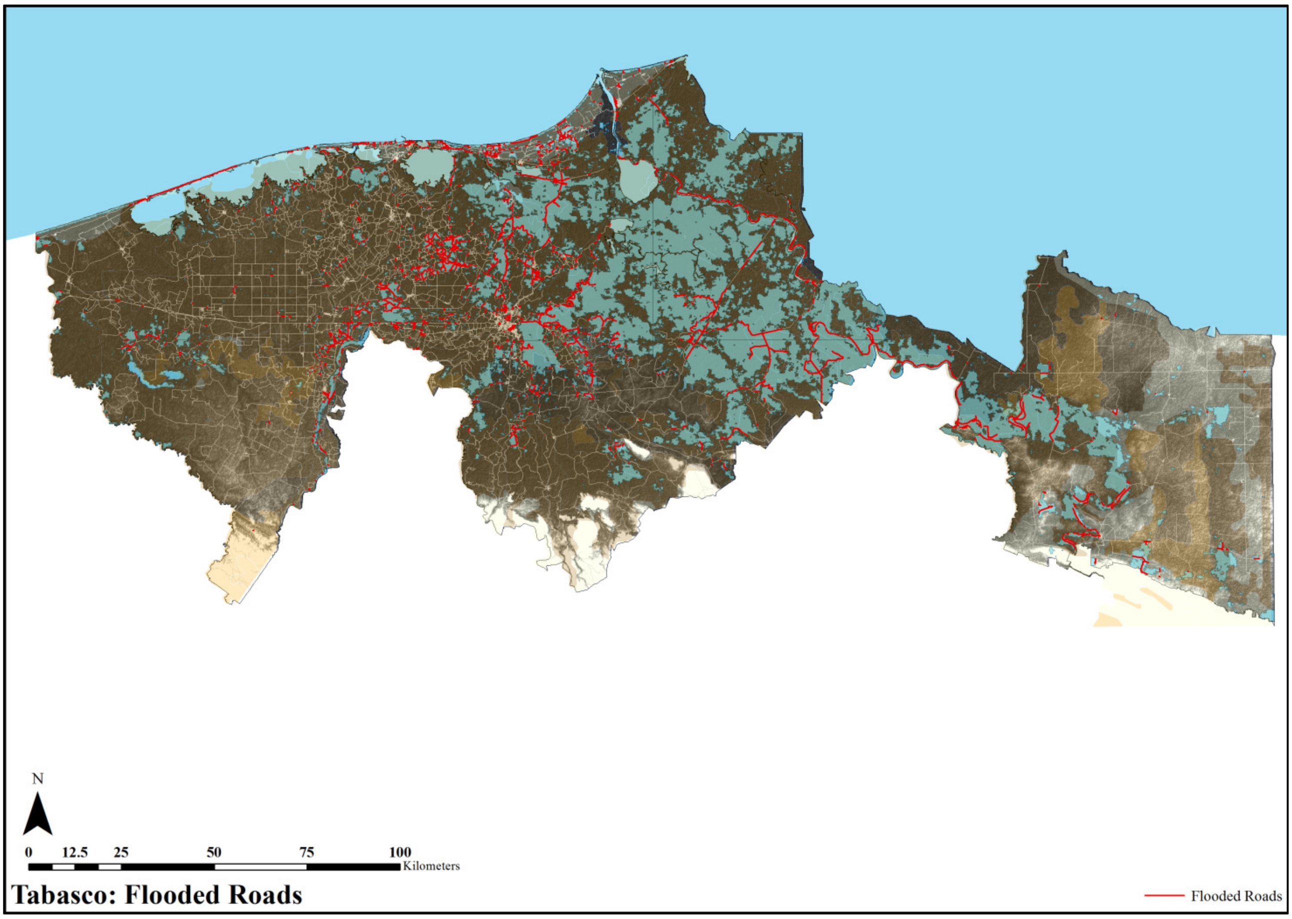

Figure 3.1: Flooded roads in the period of 28-06-2011 till 07-05-2012

The roads situated in the flooded areas are summarized in table 3.1 to table 3.5.

Road type		Soil type	Total [m]	flooded [m]	flooded [%]
1	Highways	Organic Clay	158.706	3.827	2,41%
1	Highways	Clay	10.434	0	0,00%
1	Highways	Sandy Clay	17.018	0	0,00%
1	Highways	Sandy Soil	0	0	0,00%
1	Highways	unknown	5.185	0	0,00%
Total			**191.343**	**3.827**	**2,00%**

Table 3.1: Total amount of Highways versus the flooded highways in the state Tabasco in the period of 28-06-2011 till 07-05-2012.

Road type		Soil type	Total [m]	flooded [m]	flooded [%]
2	Primary roads	Organic Clay	845.559	139.008	16,44%
2	Primary roads	Clay	106.062	4.316	4,07%
2	Primary roads	Sandy Clay	29.505	0	0,00%
2	Primary roads	Sandy Soil	85.932	10.602	12,34%
2	Primary roads	unknown	14.965	0	0,00%
Total			**1.082.023**	**153.926**	**14,23%**

Table 3.2: Total amount of primary roads versus the flooded primary roads in the state Tabasco in the period of 28-06-2011 till 07-05-2012.

Road type		Soil type	Total [m]	flooded [m]	flooded [%]
3	Secondary roads	Organic Clay	797.955	120.790	15,14%
3	Secondary roads	Clay	195.091	19.427	9,96%
3	Secondary roads	Sandy Clay	78.580	3.192	4,06%
3	Secondary roads	Sandy Soil	95.170	2.667	2,80%
3	Secondary roads	unknown	3.781	0	0,00%
Total			**1.170.577**	**146.076**	**12,48%**

Table 3.3: Total amount of secondary roads versus the flooded secondary roads in the state Tabasco in the period of 28-06-2011 till 07-05-2012.

Road type		Soil type	Total [m]	flooded [m]	flooded [%]
4	Rural Roads	Organic Clay	6.509.671	837.955	12,87%
4	Rural Roads	Clay	671.618	64.045	9,54%
4	Rural Roads	Sandy Clay	441.685	6.767	1,53%
4	Rural Roads	Sandy Soil	1.013.716	156.401	15,43%
4	Rural Roads	unknown	46.424	0	0,00%
Total			**8.683.114**	**1.065.168**	**12,27%**

Table 3.4: Total amount of rural roads versus the flooded rural roads in the state Tabasco in the period of 28-06-2011 till 07-05-2012.

Road type		Soil type	Total [m]	flooded [m]	[%]
5	Access roads	Organic Clay	457.349	43.802	9,58%
5	Access roads	Clay	49.821	1.686	3,38%
5	Access roads	Sandy Clay	5.602	0	0,00%
5	Access roads	Sandy Soil	89.639	11.922	13,30%
5	Access roads	unknown	1.646	0	0,00%
Total			**604.057**	**57.410**	**9,50%**

Table 3.5: Total amount of access roads versus the flooded access roads in the state Tabasco in the period of 28-06-2011 till 07-05-2012.

In figure 3.2 the extent of the floods are shown

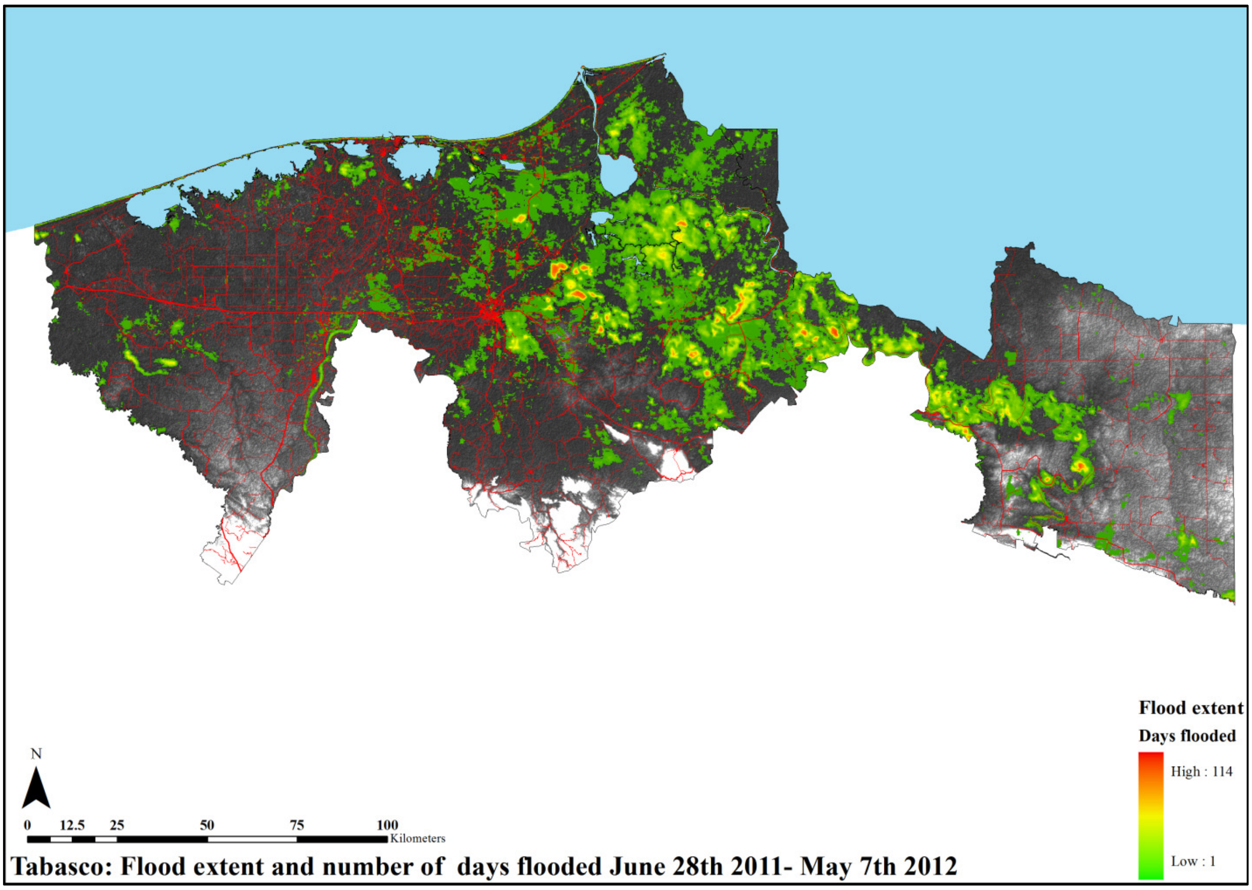

Figure 3.2: Flood extends including the frequency

3.3 Land use data

In this paragraph the information regarding the land use is expanded under the following topics:

- Soil types.
- Road infrastructure.

3.3.1 Soil type

Tabasco soils were formed in the Quaternary period of geological time scale which started some 2,500 million years. This is the last of the geological periods comprising in the recent period of glacial cycles.

Tabasco soils were formed as a result of:

1. Volcanic eruptions, where the magma rapidly cooled on the surface, solidified and produced rocks with microscopic crystals, termed, extrusive volcanic rocks.
2. The production of alluvial sands or the Mud Rivers caused after heavy rains or snowmelt floods caused, as a result of earthquakes or volcanic eruptions that carry with them silt, sand, rocks, among others.

In the State of Tabasco, the State Forestry Commission, an agency of the Ministry of Agricultural Development, Forestry and Fisheries of the State, conducted a study of soils in which the criteria were taken of soil types (drainage, texture, depth and pH), rainfall and altitude.

Based on this study the comparison was made between the taxonomy of the FAO/UNESCO and the nomenclature of the Unified Soil Classification System (USCS).

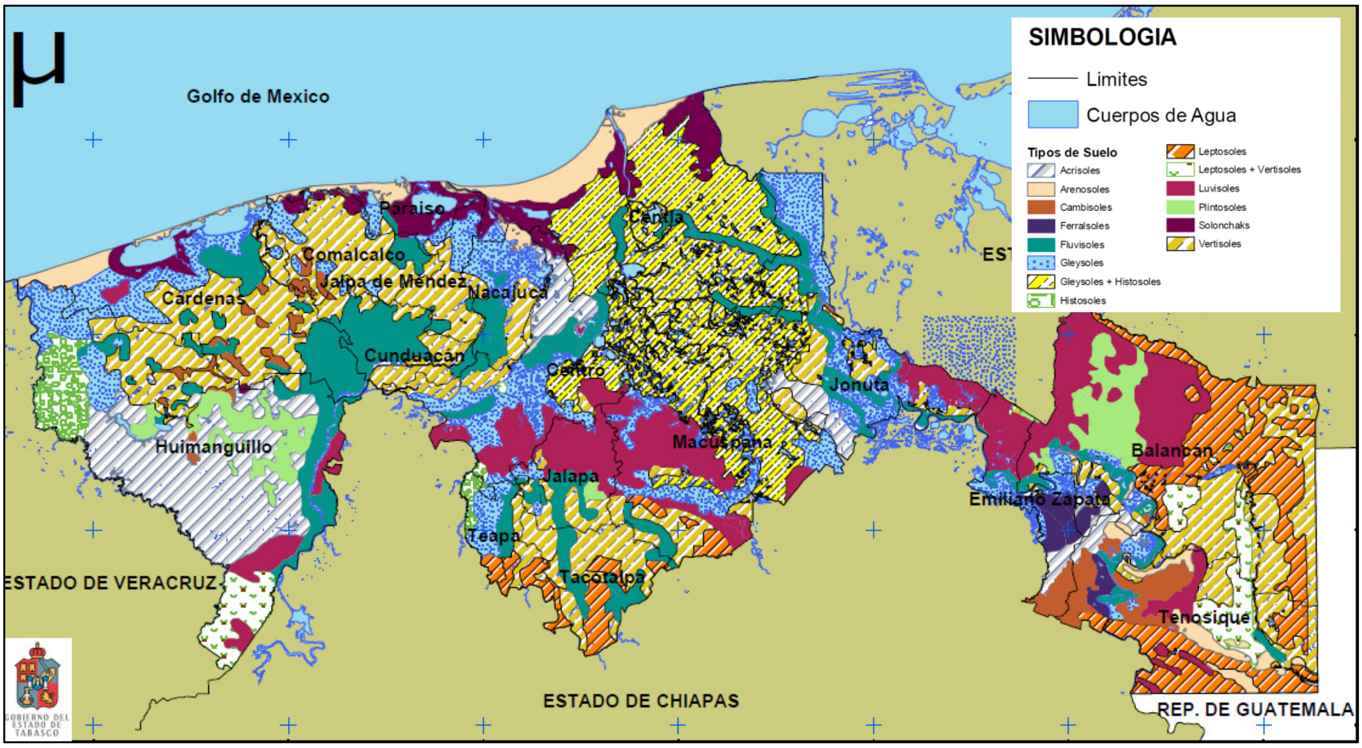

Figure 3.3: Taxonomy of the FAO/UNESCO or the World Reference Base for Soil Resource

To use the soil types for the calculations of the model the soil taxonomy is reclassified into four main groups which will be used for this study:

- Soil type 1: Organic clay.
- Soil type 2: Clay.
- Soil type 3: Sandy clay.
- Soil type 4: Sand.

In table 3.6: The reclassification given.

Taxonomy	Acrisols	Arenasols	Cambisols	Ferral sols	Fluvisols	Gleysoles	Histosols	Leptosols	Luvisols	Plinthosols	Solonchaks	Vertisols
USCS	CH OH P	SP SM	GW GM SW SM ML	OL OH	SP SC OL OH P	OL OH P	P	GW GP GM GC	SC GC CL	CL CH	OL OH P	CH OH
Main group	Soil type 4: Organic clays	Soil type 1: Sand	Soil type 1: Sand	Soil type 4: Organic clays	Soil type 4: Organic clays	Soil type 4: Organic clays	Soil type 4: Organic clays	Soil type 1: Sand	Soil type 2: Sandy clay	Soil type 3: Clay	Soil type 4: Organic clays	Soil type 4: Organic clays

Table 3.6: Reclassification soil types

The most part of the state of Tabasco is covered with (organic) clays. In table 3.7 the standard physical parameters are given of the 4 main groups of soils. Beside these is the ratio of the soil occurring in Tabasco.

Soil type	**Surface**		**Bearing capacity**
	[km^2]	[%]	[Edyn]
1 Organic clay	18.334	72%	25 N/mm^2
2 Clay	2.615	10%	50 N/mm^2
3 Sandy Clay	1.585	6%	75 N/mm^2
4 Sandy soil	3.098	12%	100 N/mm^2
Total	**25.632**	**72%**	

Table 3.7: Amounts of soil per soil type

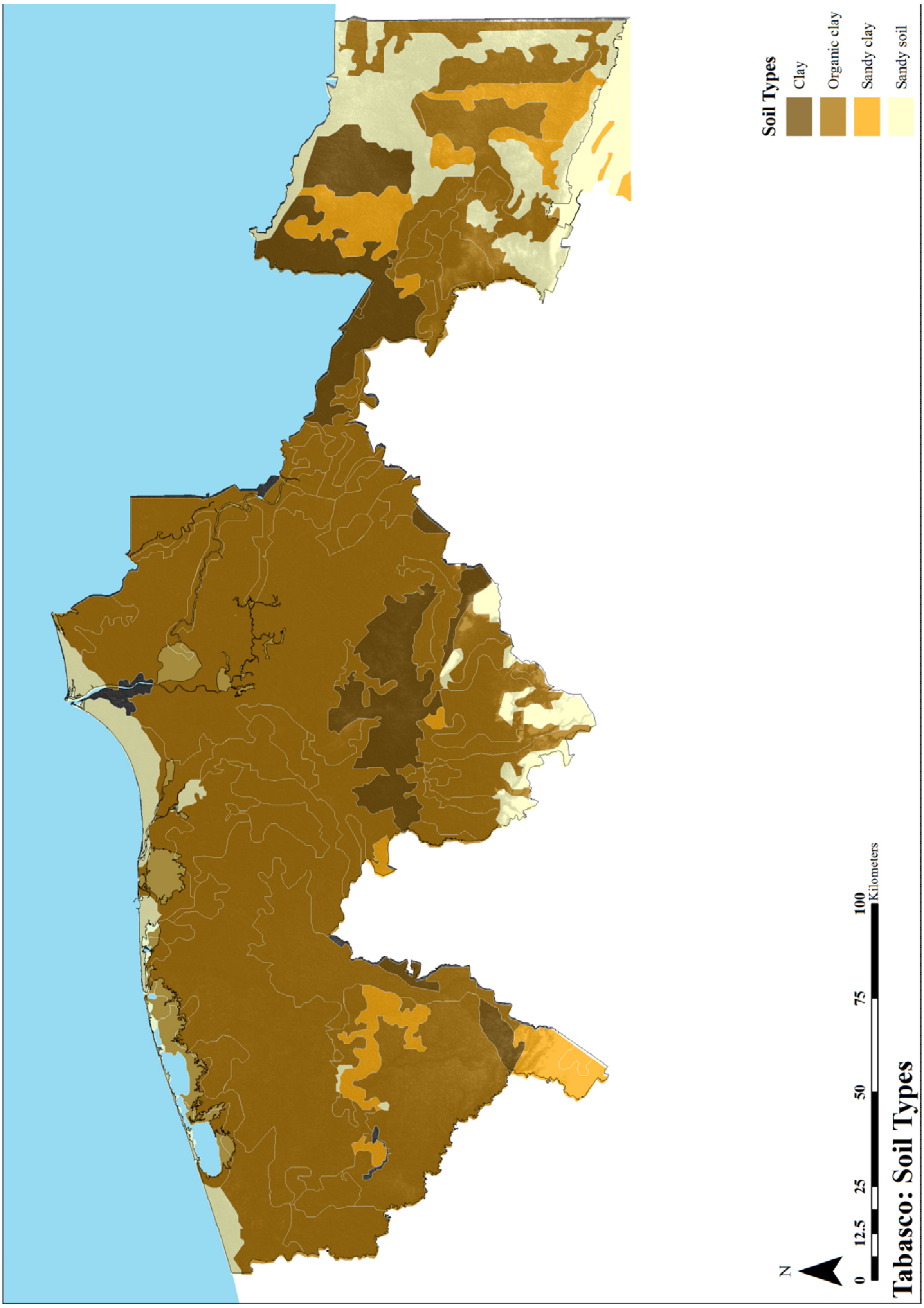

Figure 3.4: Soil map Tabasco

3.3.2 Road infrastructure

The SCT has a classification for the Road infrastructure in Mexico. In this classification the roads are divided into five classes:

- Road type 1: Highways
- Road type 2: Primary roads
- Road type 3: Secondary roads
- Road type 4: Rural roads
- Road type 5: Access roads

The traffic classes are determined on the basis of the expected traffic intensity. For this study the same classification system will be used. In figure 3.3 the road infrastructure of Tabasco is shown.

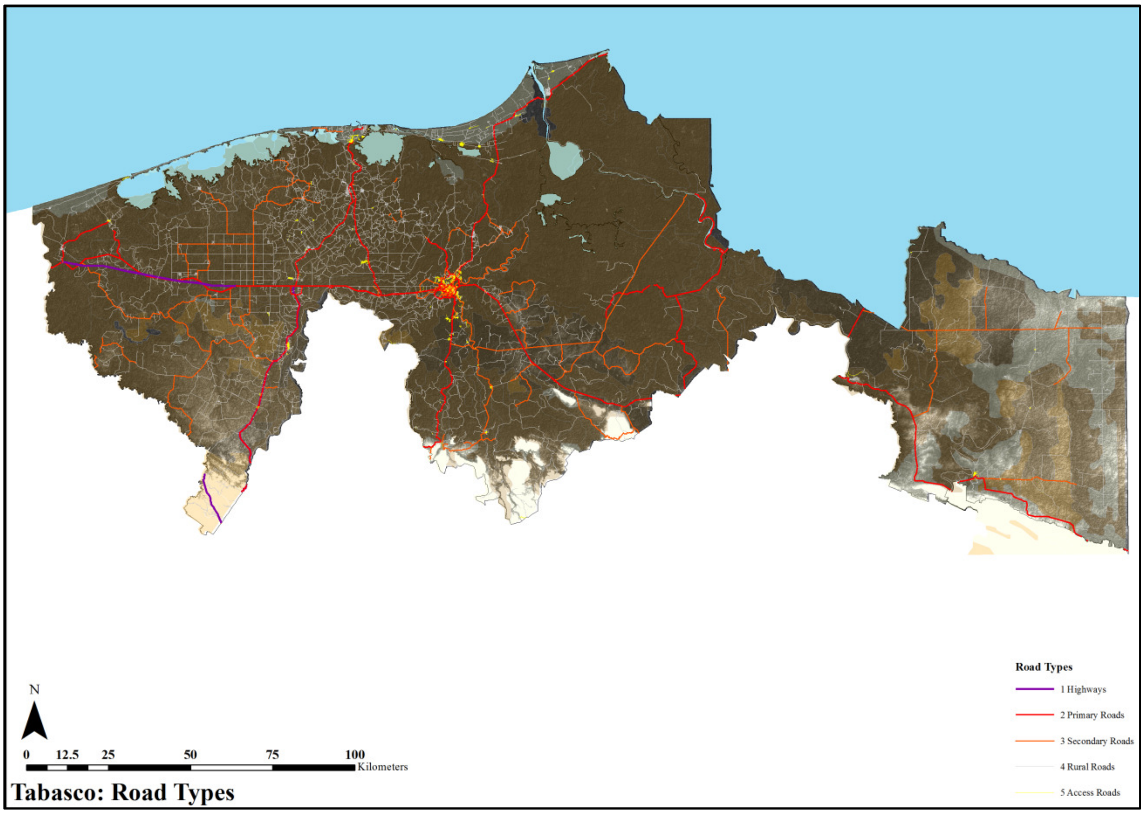

Figure 3.5: Map of the different road types in Tabasco

Road type 1: Highways

The truck traffic intensity is around 750 per day, each direction. The number of cars is estimated to be 12,000 cars a day in one direction. The width of this highway is approximately 24 meters. The total length of highways in Tabasco included in the model is 191 km.

Figure 3.6: Road profile of the highway

Road type 2: Primary roads
The truck traffic intensity is around 500 per day in one direction. The number of cars is estimated to be 5,000 cars a day in one direction. The width of this primary road is approximately 12 meters. The total length of this type of primary road in Tabasco included in the model 1082 km.

Figure 3.7: Road profile of the primary road

Road type 3: Secondary roads
The truck traffic intensity is around 250 per day in one direction. The number of cars is estimated to be 2,500 cars a day in one direction. The width of this secondary road is approximately 9 meters. The total length of this type of secondary road in Tabasco included in the model 1171 km.

Figure 3.8: Road profile of the secondary road

Road type 4: Rural roads
The truck traffic intensity is around 125 a day in one direction. The number of cars is estimated to be 1,250 cars a day in one direction. The width of this rural road is approximately 7 meters. The total length of this type of rural road in Tabasco included in the model is 8683 km.

Figure 3.9: Road profile of the rural road

Road type 5: Access roads
The truck traffic intensity is around 50 a day in one direction. The number of cars is estimated to be 500 cars a day in one direction. The width of these access roads is approximately 6 meters. The total length of this type of access road in Tabasco included in the model is 604 km. This amount may strongly deviate from the practice since not all the road traffic data was available.

Figure 3.10: Road profile of the access road

On the roads, in the state of Tabasco, a part of the road infrastructure already constructed using the PowerCem Technology. To validate the final model and to get an impression of the benefits of the PowerCem Technology are these roads also mapped. The information regarding the PowerCem based roads is provided by PowerCem Mexico and is shown in figure 3.11.

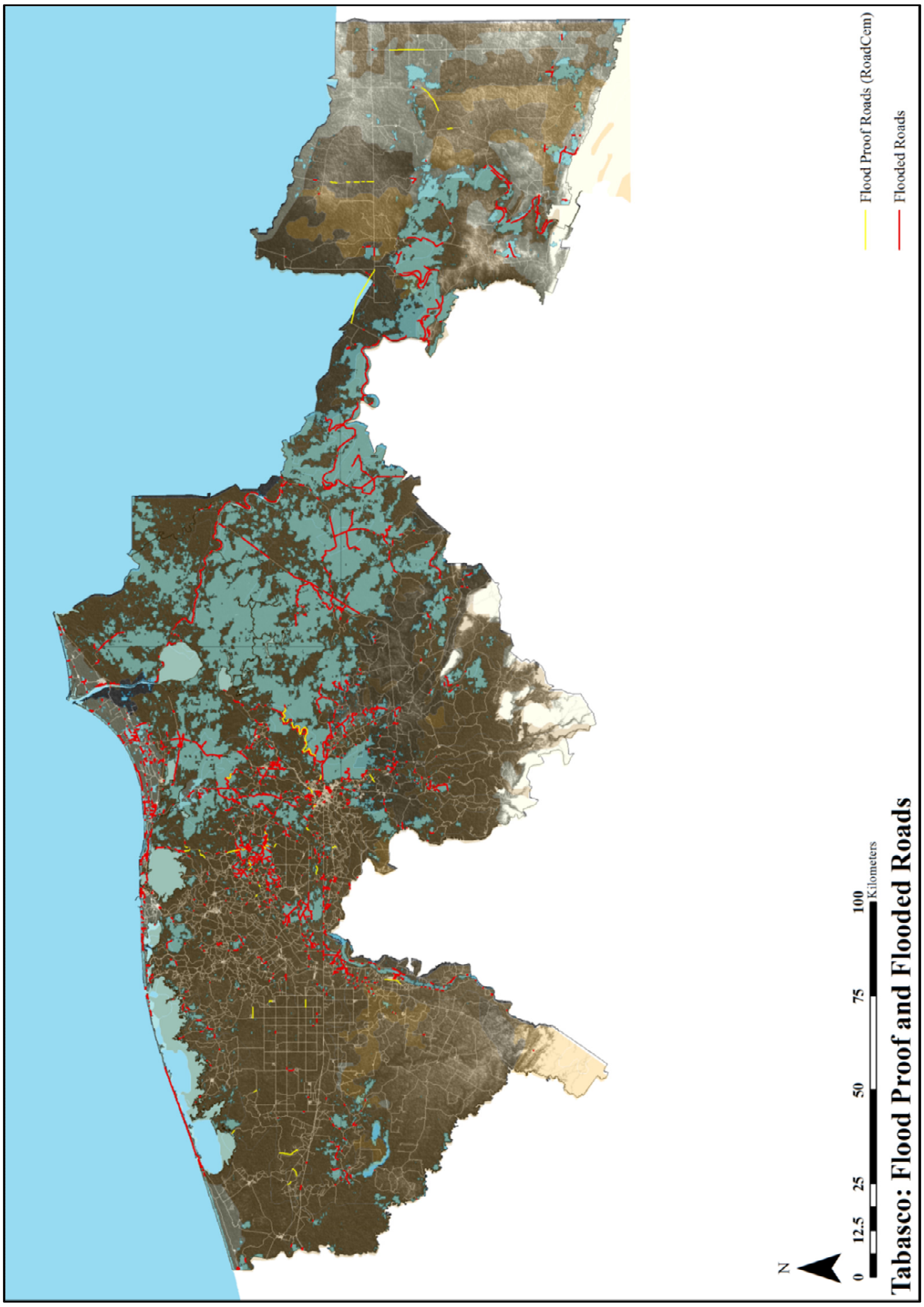

Figure 3.11: Roads in Tabasco with and without RoadCem

3.4 Constructions

For this study standard constructions are used. Traditional constructions are based on standard constructions and roads based on the use of the PowerCem technology are calculated by PowerCem Technologies. In this paragraph the constructions are described for the different road and soil types. Also an overview of all the constructions will be given.
The calculations of these constructions are given in appendix 2.

3.4.1 Traditional constructions

The traditional pavement constructions are constructed as shown in figure 3.12.

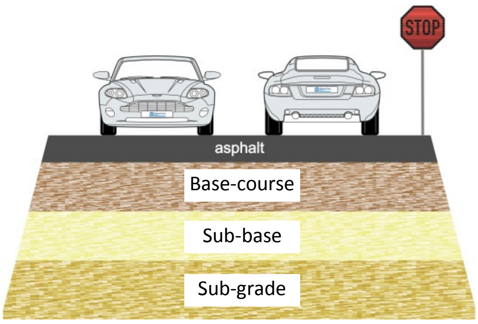

Figure 3.12: Traditional construction

Sub grade
For the soil types 1&2, an improvement of the subgrade is required, due to the low bearing capacity of the soil. The improvement of the sub grade will be made with a layer of sand. The stiffness of the sand layer is dependent on the sub soil.

Sub-base
On top of the sub-grade or the soil, a sub-base will be applied. This sub-base consists of a well graded and well compacted layer of sand. The thickness of this layer is 0,25m and the stiffness is E_{dyn}: 150 MPa.

Base course
For all of the construction, a base-course of a granular material will be applied. The thickness of this layer will be 0,25m and the stiffness of this layer will be E_{dyn}: 600 MPa.

Surface layer
The surface layer consists of asphalt. The thickness of this layer depends on the soil type and the expected traffic intensity.

The constructions are calculated for the different soil types and traffic intensity. The results are presented in table 3.8. The pavement calculations of the constructions are given in appendix 2

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Traditional	Soil 1	Soil 2	Soil 3	Soil 4
Road 1	170 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	160 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	160 mm asphalt 250 mm topbase 300 mm subbase soil	160 mm asphalt 250 mm topbase 300 mm subbase soil
Road 2	150 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	150 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	150 mm asphalt 250 mm topbase 300 mm subbase soil	150 mm asphalt 250 mm topbase 300 mm subbase soil
Road 3	130 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	130 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	130 mm asphalt 250 mm topbase 300 mm subbase soil	130 mm asphalt 250 mm topbase 300 mm subbase soil
Road 4	100 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	100 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	100 mm asphalt 250 mm topbase 300 mm subbase soil	100 mm asphalt 250 mm topbase 300 mm subbase soil
Road 5	80 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	80 mm asphalt 250 mm topbase 250 mm subbase 300 mm sand soil	80 mm asphalt 250 mm topbase 300 mm subbase soil	80 mm asphalt 250 mm topbase 300 mm subbase soil

Table 3.8: Traditional pavement constructions for the different road and soil types.

3.4.2 PowerCem based constructions

The constructions using the PowerCem technology are based on a RoadCem-cement bound base course with a surface layer on top. Figure 3.13 shows a schematic cross section of the construction.

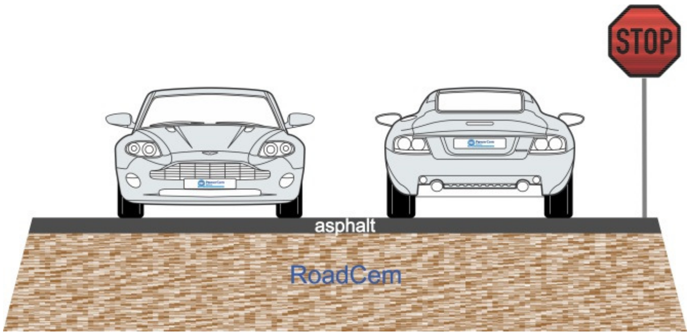


Figure 3.13: Schematic cross section of a RoadCem construction

Base-course

The base course will be formed with a mixture of RoadCem and cement. The amount of RoadCem and cement depends on the soil type which has to be bound. In table 3.3 the indicative amounts of RoadCem and cement are given for the different soil types. These amounts are used for further calculations in this study.

Soil type	Amount of RoadCem	Amount of cement
Soil type 1	2,2 kg/m^3	220 kg/m^3
Soil type 2	2,0 kg/m^3	200 kg/m^3
Soil type 3	1,8 kg/m^3	180 kg/m^3
Soil type 4	1,6 kg/m^3	160 kg/m^3
Crushed old construction	1,5 kg/m^3	150 kg/m^3

Table 3.9: Indicative amounts of RoadCem and cement

The thickness of the RoadCem-cement layer depends on:

- Bearing capacity of the soil.
- Physical properties of the RoadCem cement layer.
- Expected amount of traffic.

The different constructions for the different soil types and traffic amounts are summarized in table 3.10. The pavement calculations are given attached in appendix 3.

Wearing course

For the surface layer two different materials are used:

- Chip & Spray layer
- Asphalt surface layer

In combination with a RoadCem-cement base a Chip&Spray layer is sufficient for the most road types. A RoadCem-cement base will be the structure of the construction and the Chip&Spray acts like a friction course without any structural value.

A disadvantage is the limited "body" of this Chip&Spray layer. With a lot of maneuvering of traffic or instantaneous breaking at high speed, the Chip&Spray layer may detach. Therefore, for road types 1 & 2 a construction with an asphalt wearing course is desirable.

RoadCem - cement	Soil 1	Soil 2	Soil 3	Soil 4	Reconstruction of the traditional construction
Road 1	50 mm asphalt 310 mm RoadCem - cement soil	50 mm asphalt 280 mm RoadCem - cement soil	50 mm asphalt 260 mm RoadCem - cement soil	50 mm asphalt 250 mm RoadCem - cement soil	50 mm asphalt 250 mm RoadCem - cement soil
Road 2	50 mm asphalt 300 mm RoadCem - cement soil	50 mm asphalt 270 mm RoadCem - cement soil	50 mm asphalt 250 mm RoadCem - cement soil	50 mm asphalt 240 mm RoadCem - cement soil	50 mm asphalt 240 mm RoadCem - cement soil
Road 3	- mm C&S 330 mm RoadCem - cement soil	- mm C&S 300 mm RoadCem - cement soil	- mm C&S 280 mm RoadCem - cement soil	- mm C&S 270 mm RoadCem - cement soil	- mm C&S 270 mm RoadCem - cement soil
Road 4	- mm C&S 310 mm RoadCem - cement soil	- mm C&S 280 mm RoadCem - cement soil	- mm C&S 260 mm RoadCem - cement soil	- mm C&S 250 mm RoadCem - cement soil	- mm C&S 250 mm RoadCem - cement soil
Road 5	- mm C&S 290 mm RoadCem - cement soil	- mm C&S 260 mm RoadCem - cement soil	- mm C&S 240 mm RoadCem - cement soil	- mm C&S 230 mm RoadCem - cement soil	- mm C&S 230 mm RoadCem - cement soil

Table 3.10: RoadCem pavement construction

3.5 Damage mechanisms

A road might be damaged in many different ways and may display different signs of damage; Factors to observe are:

- Seriousness of the damage.
- Scope of the damage.
- Type of road.

In this study the focus is on damage as result of flooding. There is an overlap with the structural damages due to the accepted wear and tear of the lifetime of the road. The age of the road will therefore have a major influence. Damaged or weakened parts of a road will easily be worsened by flooding.

For possible damages a distinction is made for that caused directly or indirectly by floods.

- **Directly**
  Direct damage of a road is readily noticed. In most cases this will be caused by erosion of floating water. Therefore the road may be completely washed away. Roads which are built on dikes or embankments will have other possible failure mechanisms, which are also show signs of direct damage.
- **Indirectly**
  When a road construction remains under water for a while, the water will penetrate into the pavement construction. Saturated unbound materials have a disadvantage in that they lose their strength. When the unbound materials in a road construction are saturated and the road is trafficked the bound materials will be over loaded and the lifetime of the construction will be reduced significantly. However this failure is mainly caused by flooding, and this failure will not always be related to the flood. These failures will therefore not be included in the calculations.

Using the flooding data the total amount of roads, which were actually flooded, can be determined. Not all of these roads are expected to be damaged. To get an accurate impression of the actual damaged roads the ratio between flooded roads and actual damaged roads is determined. Since this data is not available yet for the state Tabasco, assumptions are made based on expert judgment.

It is known that a significant amount of the flooded roads are so damaged that a total reconstruction of the road is required. Smaller damages on the roads are not always directly noticed and these disadvantages are encountered only after some time. So this study is focused on roads totally destroyed by floods. Heavier constructions are expected to be less sensitive flood damage in comparison with lighter constructions. So a distinction is made for each road type. In table 3.11 the assumed percentages of damaged roads in relation to flooded roads are given.

Road Type:	**Assumed percentage of damaged roads**
1. Highways	10%
2. Primary roads	15%
3. Secondary roads	45%
4. Rural Roads	55%
5. Access roads	65%

Table 3.11: Assumed percentage of damaged roads in relation to the flooded roads per road type

3.6 Maintenance policy

Maintenance of the infrastructure is important for the quality and the accessibility of the roads. However there are two ways to manage the required maintenance:

- **Reactive policy**
  Maintenance will be carried out when a road is damaged.
- **Proactive policy**
  Maintenance will be carried out before a road can be damaged.

In most areas of the world road infrastructure is managed by a reactive policy. This means that maintenance will be carried out when:

- Road is actually damaged.
- Cause of the damage is known.

However, in flood risk areas the main disadvantage is that when a flood occurs, all the roads in the affected area will be damaged at once. And there are no or limited alternative roads available. This could lead to the situation whereby, after a flood, villages or cities could be isolated. In this case a proactive policy is more appropriate.

With a proactive policy, possible damages will be prevented and the roads will be available directly after a flood. With traditional systems in the past a proactive policy was mostly not feasible. Now, PowerCem technology offers new opportunities.

3.6.1 Reactive policy

For a reactive policy it is assumed that the traditional construction as given in paragraph 3.4 will be damaged as result of a flood.

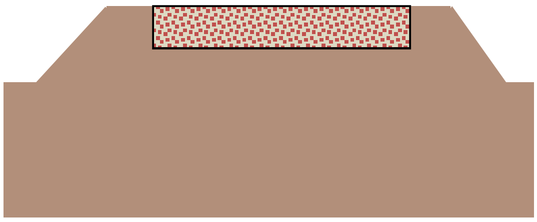


Figure 3.14: Schematic cross section of a traditional construction

During a flood the road will be damaged by erosion. In this study it is assumed that all the roads will be damaged in such a way that the complete construction has to be renewed. Figure 3.15 shows the schematic damage of the road.

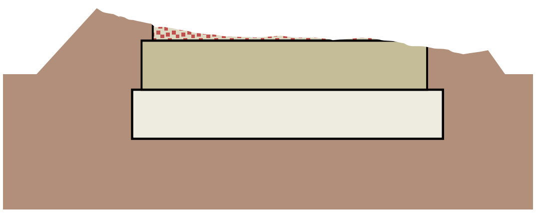
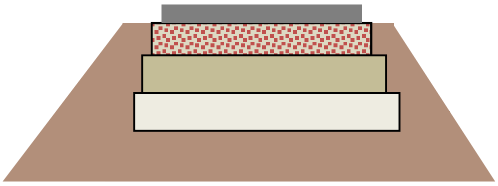


Figure 3.15: Schematic cross section of a damage road

A damaged road can be rehabilitated in two different ways:

1. Rehabilitation in the traditional way.
2. Rehabilitation using the PowerCem technology.

Traditional:	RoadCem- cement
 *Figure 3.16: Remediation in traditional way.*	 *Figure 3.17: Remediation using the PowerCem technology*

Traditional reconstruction

For the traditional reconstruction of a damaged road, the road will be rebuilt with the same materials as before.

After a flood the site has to be cleared of debris from the old damaged road construction, vegetation and other washed up waste. Following the soil has to be compacted and leveled. Before construction works can be started, the water table must sufficiently be decreased. A saturated soil will not have enough bearing capacity what will lead to an early failure of the new construction.

After the preparation of the site the new construction as described in paragraph 3.4 will be reconstructed.

Reconstruction using the PowerCem Technology

The damaged road will be rebuilt using the PowerCem Technology. For the calculations it is assumed that the old road construction is completely washed away. If the old construction partly remains on the site, the debris can be crushed and reused in the new construction.

First the embankments have to be filled to the required levels. This can be done with all soils or other granular material which are available on the site. Following this, the top soil has to be stabilized with RoadCem and cement at the required thickness. The amounts of RoadCem, cement and the required thickness are given in paragraph 3.4.

3.6.2 Proactive policy

In a proactive policy maintenance will be carried out before possible damage can occur. In the event of flooding, there are limited possibilities to carry out a proactive maintenance policy with a traditional system. New traditional road construction may also be damaged.

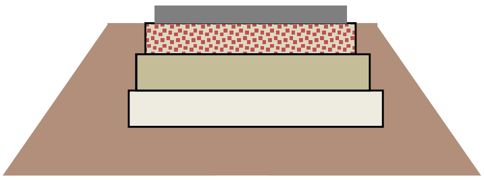
Traditional:	**RoadCem- cement**
	
Proactive maintenance in the traditional way is not possible.	The traditional construction will be crushed and mixed with RoadCem and cement to the required depth.

Figure 3.18: Proactive and reactive policy

The advantage of proactive policy in flood risk areas is that the blocking of the roads will be reduced to an absolute minimum. The roads can be opened for traffic directly after a flood. So nuisance to the population and industry will be reduced to a minimum. Another benefit is that the costs for the maintenance in a proactive policy are in general lower, that the maintenance costs in a reactive policy. Access to the site is easier and the surroundings are not destroyed. The cleaning of an affected area may also be a time consuming and an expensive activity.

In spite of the advantages the benefits depend on the specific case and location. The results of a proactive policy will be compared with a reactive policy in chapter 4.

3.7 Costs

To get an accurate impression of the macro-economic effects of the PowerCem technology, a distinction is made between the direct and the indirect costs. The direct costs consist of the required measures to get the infrastructure operational.
The indirect costs are the costs as result of a non-working infrastructure and are not always expressed in exact values.

The costs for the different constructions and measures are partly based on actual verified prices. Since not all the verified prices were available, the rest of the costs are assumed based on expert judgment.

The costs used for the study are extended by the following topics:

- Unit prices.
- Traditional constructions.
- RoadCem constructions.
- Measures.
- Indirect costs.

3.7.1 Unit prices

In this sub-paragraph all the unit prices are given which are further calculated. The unit prices are divided in the following topics:

- Material costs.
- Construction costs.

Materials

All the materials used for the different constructions are summarized in table 3.12.

Materials	Costs
Cement	$ 1.700,00 ton
RoadCem	$ 396,00 kg
Water pipe not potable	$ 50,00 m^3
Chip & Spray	$ 121,00 m^2
Asphalt	$ 8.450,00 m^3
Sub-grade material	$ 157,00 m^3
Sub-base material	$ 157,00 m^3
Base-course material	$ 180,00 m^3

Table 3.12: Material prices

Construction

The costs for the different constructions are summarized in table 3.13

Equipment	Costs
Grader	$ 788,87 hour
Compactor (sheeps foot)	$ 454,27 hour
Compactor	$ 442,42 hour
Excavator	$ 1.200,00 hour

Table 3.13: Prices equipment

3.7.2 Traditional constructions

In this paragraph the cost calculation are given for the reconstruction of a damaged road. The calculations are based on the unit prices given in paragraph 3.7.1. The construction of the traditional construction is divided in 6 steps:

- Step 1: Excavation and preparation.
- Step 2: Leveling and pre-compaction.
- Step 3: Applying Sub-grade material.
- Step 4: Applying Sub-base material.
- Step 5: Applying Base-course material.
- Step 6: Applying Wearing course.

In appendix 4 the cost calculation is given for the steps. The total costs are presented in tables 3.14 to table 3.18 and are the construction costs summarized per Road type.

Roadtype 1: Highways					
		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Step 1	Excavation/ scarifying/preparation	$ 40,96	$ 40,54	$ 29,98	$ 29,98
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	Applying Sub-grade	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Step 4	Applying Sub-base	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Step 5	Applying Base-Course	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Step 6	Wearing course	$ 1.436,50	$ 1.352,00	$ 1.352,00	$ 1.352,00
TOTAL COSTS IN MEXICAN PESOS [m²]		**$ 1.801,09**	**$ 1.716,17**	**$ 1.609,46**	**$ 1.609,46**
TOTAL COSTS IN MEXICAN PESOS [m¹]		**$ 43.226,20**	**$ 41.188,07**	**$ 38.627,14**	**$ 38.627,14**

Table 3.14: Summarized cost calculation Highways(traditional system)

Roadtype 2: Primary roads					
		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Step 1	Excavation/ scarifying/preparation	$ 40,11	$ 40,11	$ 29,56	$ 29,56
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	Applying Sub-grade	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Step 4	Applying Sub-base	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Step 5	Applying Base-Course	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Step 6	Wearing course	$ 1.267,50	$ 1.267,50	$ 1.267,50	$ 1.267,50
TOTAL COSTS IN MEXICAN PESOS [m²]		**$ 1.631,25**	**$ 1.631,25**	**$ 1.524,54**	**$ 1.524,54**
TOTAL COSTS IN MEXICAN PESOS [m¹]		**$ 19.574,97**	**$ 19.574,97**	**$ 18.294,50**	**$ 18.294,50**

Table 3.15: Summarized cost calculation Primary roads(traditional system)

Roadtype 3: Secondary roads					
		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Step 1	Excavation/ scarifying/preparation	$ 39,27	$ 39,27	$ 28,71	$ 28,71
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	Applying Sub-grade	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Step 4	Applying Sub-base	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Step 5	Applying Base-Course	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Step 6	Wearing course	$ 1.098,50	$ 1.098,50	$ 1.098,50	$ 1.098,50
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 1.461,40**	**$ 1.461,40**	**$ 1.354,70**	**$ 1.354,70**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 13.152,62**	**$ 13.152,62**	**$ 12.192,28**	**$ 12.192,28**

Table 3.16: Summarized cost calculation secondary roads(traditional system)

Roadtype 4: Rural Roads					
		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Step 1	Excavation/ scarifying/preparation	$ 38,00	$ 38,00	$ 27,45	$ 27,45
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	Applying Sub-grade	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Step 4	Applying Sub-base	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Step 5	Applying Base-Course	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Step 6	Wearing course	$ 845,00	$ 845,00	$ 845,00	$ 845,00
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 1.206,64**	**$ 1.206,64**	**$ 1.099,93**	**$ 1.099,93**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 8.446,45**	**$ 8.446,45**	**$ 7.699,51**	**$ 7.699,51**

Table 3.17: Summarized cost calculation Rural roads(traditional system)

Roadtype 5: Acces Roads					
		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Step 1	Excavation/ scarifying/preparation	$ 37,16	$ 37,16	$ 26,60	$ 26,60
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	Applying Sub-grade	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Step 4	Applying Sub-base	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Step 5	Applying Base-Course	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Step 6	Wearing course	$ 676,00	$ 676,00	$ 676,00	$ 676,00
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 1.036,79**	**$ 1.036,79**	**$ 930,09**	**$ 930,09**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 6.220,75**	**$ 6.220,75**	**$ 5.580,52**	**$ 5.580,52**

Table 3.18: Summarized cost calculation Highways(traditional system)

3.7.3 RoadCem construction

The costs for the RoadCem construction are as follows; in this paragraph these costs are extended based on the unit costs given in paragraph 3.7.2. The construction of the RoadCem construction is divided in 5 steps

- Step 1: Scarifying, excavation and preparation.
- Step 2: Leveling and pre-compaction.
- Step 3: Applying RoadCem and Cement.
- Step 4: Curing.
- Step 5 Wearing courses.

In appendix 4 the cost calculation is given for the steps. The total costs are presented in table 3.19 to table 3.23 the construction costs are summarized for each road type.

Roadtype 1: Highways	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Step 1 Excavation/ scarifying/preparation	$ 13,09	$ 11,82	$ 10,98	$ 10,56	$ 10,56
Step 2 Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3 applying RC & cement	$ 543,33	$ 451,77	$ 383,31	$ 333,77	$ 316,37
Step 4 Curing	$ 2,18	$ 2,18	$ 2,18	$ 2,18	$ 2,18
Step 5 Wearing course	$ 422,50	$ 422,50	$ 422,50	$ 422,50	$ 422,50
TOTAL COSTS IN MEXICAN PESOS [m^2]	**$ 989,98**	**$ 897,16**	**$ 827,85**	**$ 777,89**	**$ 760,49**
TOTAL COSTS IN MEXICAN PESOS [m^1]	**$ 23.759,57**	**$ 21.531,79**	**$ 19.868,50**	**$ 18.669,38**	**$ 18.251,80**

Table 3.19: Summarized cost calculation Highways

Roadtype 2: Primary roads	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Step 1 Excavation/ scarifying/preparation	$ 12,67	$ 11,40	$ 10,56	$ 10,13	$ 10,13
Step 2 Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3 applying RC & cement	$ 525,80	$ 435,64	$ 368,57	$ 320,42	$ 303,72
Step 4 Curing	$ 2,18	$ 2,18	$ 2,18	$ 2,18	$ 2,18
Step 5 Wearing course	$ 422,50	$ 422,50	$ 422,50	$ 422,50	$ 422,50
TOTAL COSTS IN MEXICAN PESOS [m^2]	**$ 972,03**	**$ 880,60**	**$ 812,69**	**$ 764,12**	**$ 747,41**
TOTAL COSTS IN MEXICAN PESOS [m^1]	**$ 11.664,40**	**$ 10.567,21**	**$ 9.752,27**	**$ 9.169,41**	**$ 8.968,98**

Table 3.20: Summarized cost calculation primary roads

Roadtype 3: Secondary roads		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Step 1	Excavation/ scarifying/preparation	$ 13,93	$ 12,67	$ 11,82	$ 11,40	$ 11,40
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	applying RC & cement	$ 578,38	$ 484,04	$ 412,80	$ 360,47	$ 341,68
Step 4	Curing	$ 2,18	$ 2,18	$ 2,18	$ 2,18	$ 2,18
Step 5	Wearing course	$ 121,00	$ 121,00	$ 121,00	$ 121,00	$ 121,00
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 724,38**	**$ 628,77**	**$ 556,68**	**$ 503,94**	**$ 485,15**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 6.519,42**	**$ 5.658,95**	**$ 5.010,16**	**$ 4.535,43**	**$ 4.366,32**

Table 3.21: Summarized cost calculation Secondary roads

Roadtype 4: Rural roads		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Step 1	Excavation/ scarifying/preparation	$ 13,09	$ 11,82	$ 10,98	$ 10,56	$ 10,56
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	applying RC & cement	$ 543,33	$ 451,77	$ 383,31	$ 333,77	$ 316,37
Step 4	Curing	$ 2,18	$ 2,18	$ 2,18	$ 2,18	$ 2,18
Step 5	Wearing course	$ 121,00	$ 121,00	$ 121,00	$ 121,00	$ 121,00
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 688,48**	**$ 595,66**	**$ 526,35**	**$ 476,39**	**$ 458,99**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 4.819,37**	**$ 4.169,61**	**$ 3.684,48**	**$ 3.334,74**	**$ 3.212,94**

Table 3.22: Summarized cost calculation Rural roads

Roadtype 5: Acces roads		Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Step 1	Excavation/ scarifying/preparation	$ 12,25	$ 10,98	$ 10,13	$ 9,71	$ 9,71
Step 2	Leveling and precompaction	$ 8,89	$ 8,89	$ 8,89	$ 8,89	$ 8,89
Step 3	applying RC & cement	$ 508,27	$ 419,50	$ 353,83	$ 307,07	$ 291,06
Step 4	Curing	$ 2,18	$ 2,18	$ 2,18	$ 2,18	$ 2,18
Step 5	Wearing course	$ 121,00	$ 121,00	$ 121,00	$ 121,00	$ 121,00
TOTAL COSTS IN MEXICAN PESOS [m^2]		**$ 652,58**	**$ 562,54**	**$ 496,02**	**$ 448,84**	**$ 432,84**
TOTAL COSTS IN MEXICAN PESOS [m^1]		**$ 3.915,50**	**$ 3.375,26**	**$ 2.976,14**	**$ 2.693,07**	**$ 2.597,02**

Table 3.23: Summarized cost calculation Access roads

3.7.4 Indirect costs

The road infrastructure is one of the most essential factors for the economics of a region. Without a road network there is no, or limited transportation possible. In addition to the basic necessity of life like the supply of food and medical care, trade is not possible. This could have an enormous influence on the economics of that region.

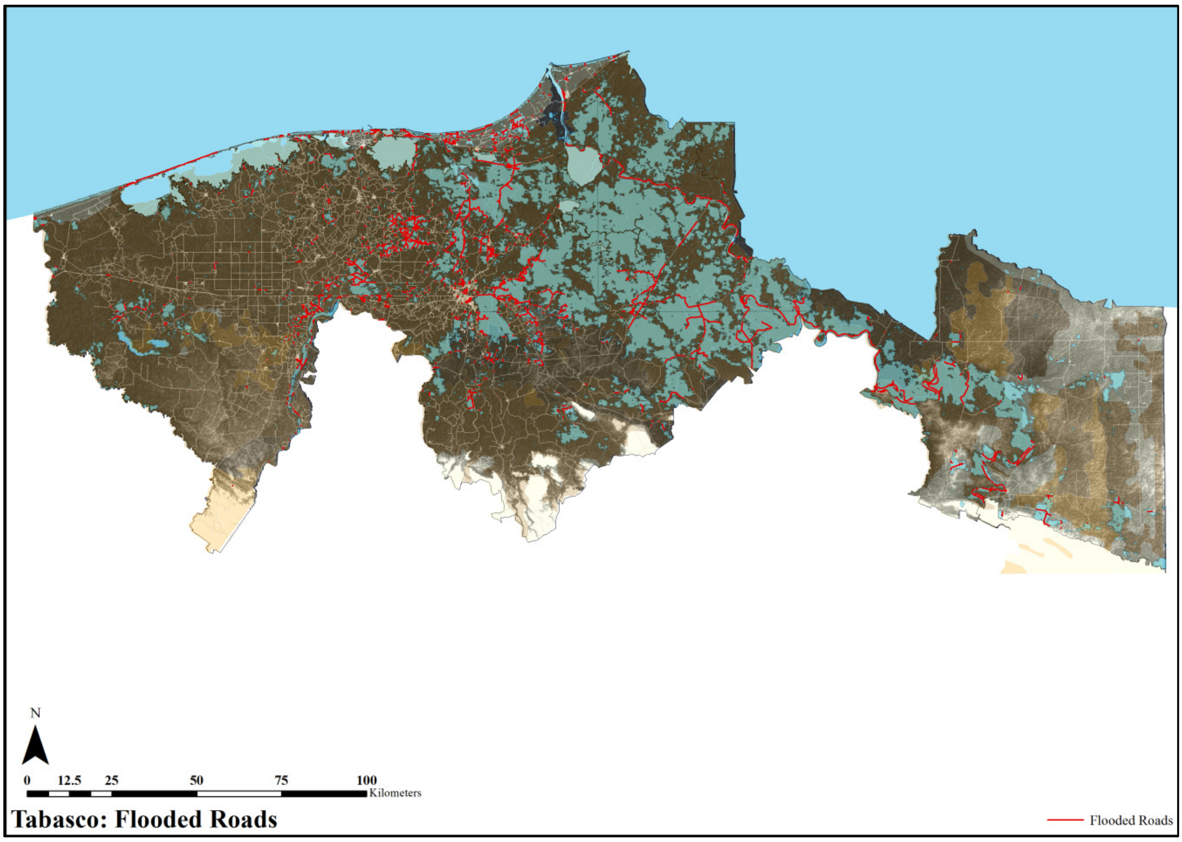
For example: farmers have to throw away their harvests after a flood, even when the harvests have not been destroyed. Industries have to close because they cannot transport their goods. Therefore the availability of the road network is more important for the economics of the region than just the maintenance costs.
These costs which are not always expressed in exact values are the indirect costs.

4 Application in the state Tabasco

4.1 General

To build a model it is important to use an area where the output can be checked with the input. A successful model is based on the fact that there is a clear relationship between the input and the output. For the state of Tabasco the model is applied, to determine the macro economic effects.

In this chapter the following items are discussed. The direct macroeconomic costs are described and the interpretation of the indirect costs is described for several specific areas.



4.2 Floods: Infrastructure versus Economics

4.2.1 Maintenance costs

The maintenance costs for the road infrastructure depending on the extent of the floods and assumed damage percentages as described in chapter 3. In table 4.1 the total amounts of roads are shown.

Type of road		Flooded roads				
		Soil type 1 [m]	Soil type 2 [m]	Soil type 3 [m]	Soil type 4 [m]	**Totals [m]**
Roadtype 1	Highways	3.827	0	0	0	3.827
Roadtype 2	Primary roads	139.008	4.316	0	10.602	153.926
Roadtype 3	Secondary roads	120.790	19.427	3.192	2.667	146.076
Roadtype 4	Rural roads	837.955	64.045	6.767	156.401	1.065.168
Roadtype 5	Access roads	43.802	1.686	0	11.922	57.410
Total		**1.145.382**	**89.474**	**9.959**	**181.592**	**1.426.407**

Table 4.1: Flooded roads based on the flood extents

Based on the damage percentages from table 3.11 the amount of roads per soil type assumed to be damaged are determined. The results are shown in table 4.2

Type of road		Assumed amount of damaged roads				
		Soil type 1 [m]	Soil type 2 [m]	Soil type 3 [m]	Soil type 4 [m]	**Totals [m]**
Roadtype 1	Highways	383	0	0	0	383
Roadtype 2	Primary roads	20.851	647	0	1.590	23.089
Roadtype 3	Secondary roads	54.356	8.742	1.436	1.200	65.734
Roadtype 4	Rural roads	460.875	35.225	3.722	86.021	585.842
Roadtype 5	Access roads	28.471	1.096	0	7.749	37.317
Total		**564.936**	**45.710**	**5.158**	**96.560**	**712.365**

Table 4.2: Assumed amount of damaged roads as result of the floods from 28-06-2011 till 07-05-2012

For the period of 28-6-2011 to 07-05-2012 the traditional maintenance costs are indicated in table 4.3 and the maintenance costs with RoadCem in table 4.4.

Type of road		Maintenance costs Traditional				
		Soil type 1 MEXICAN PESOS	Soil type 2 MEXICAN PESOS	Soil type 3 MEXICAN PESOS	Soil type 4 MEXICAN PESOS	**Totals** MEXICAN PESOS
Roadtype 1	Highways	$ 16.542.667,47	$ 0,00	$ 0,00	$ 0,00	$ 16.542.667,47
Roadtype 2	Primary roads	$ 408.161.552,46	$ 12.672.833,65	$ 0,00	$ 29.093.746,98	$ 449.928.133,09
Roadtype 3	Secondary roads	$ 714.917.498,52	$ 114.982.219,09	$ 17.512.985,63	$ 14.632.560,36	$ 862.045.263,60
Roadtype 4	Rural roads	$ 3.892.760.731,16	$ 297.524.164,22	$ 28.656.437,48	$ 662.316.459,09	$ 4.881.257.791,95
Roadtype 5	Access roads	$ 177.112.814,86	$ 6.817.318,98	$ 0,00	$ 43.245.098,55	$ 227.175.232,39
Total		**$ 5.209.495.264,48**	**$ 431.996.535,94**	**$ 46.169.423,11**	**$ 749.287.864,98**	**$ 6.436.949.088,51**

Table 4.3: Maintenance costs using traditional systems

Type of road		Maintenance costs RoadCem				
		Soil type 1 MEXICAN PESOS	Soil type 2 MEXICAN PESOS	Soil type 3 MEXICAN PESOS	Soil type 4 MEXICAN PESOS	Totals
Roadtype 1	Highways	$ 9.092.785,67	$ 0,00	$ 0,00	$ 0,00	$ 9.092.785,67
Roadtype 2	Primary roads	$ 243.216.649,04	$ 6.841.213,31	$ 0,00	$ 14.582.117,07	$ 264.639.979,41
Roadtype 3	Secondary roads	$ 354.366.192,07	$ 49.471.371,62	$ 7.196.590,02	$ 5.443.201,45	$ 416.477.355,16
Roadtype 4	Rural roads	$ 2.221.129.843,92	$ 146.873.333,89	$ 13.713.075,12	$ 286.855.829,94	$ 2.668.572.082,86
Roadtype 5	Access roads	$ 111.479.501,13	$ 3.698.952,13	$ 0,00	$ 20.869.388,26	$ 136.047.841,53
Total		**$ 2.939.284.971,82**	**$ 206.884.870,96**	**$ 20.909.665,14**	**$ 327.750.536,71**	**$ 3.494.830.044,63**

Table 4.4: Maintenance costs using the PowerCem technology.

In figure 4.1 and 4.2 the results are compared.

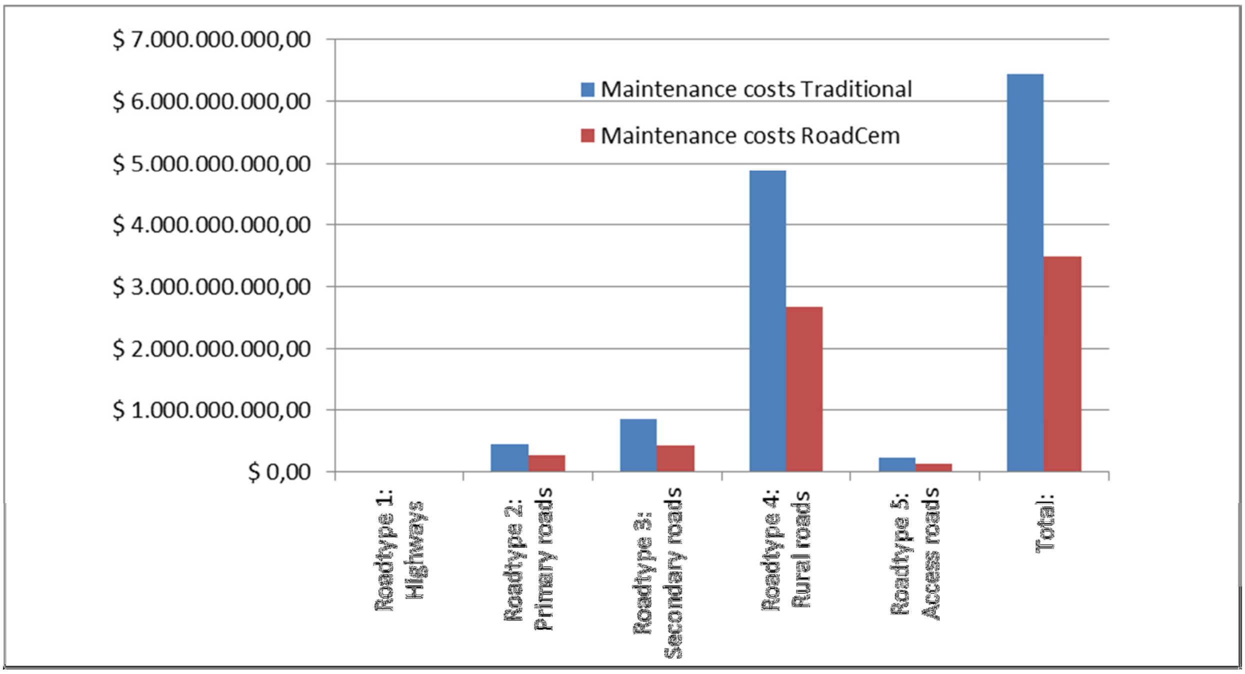


Figure 4.1: Expected maintenance costs due to the floods in the period of 28-06-2012 to 07-05-2012 in Mexican Pesos

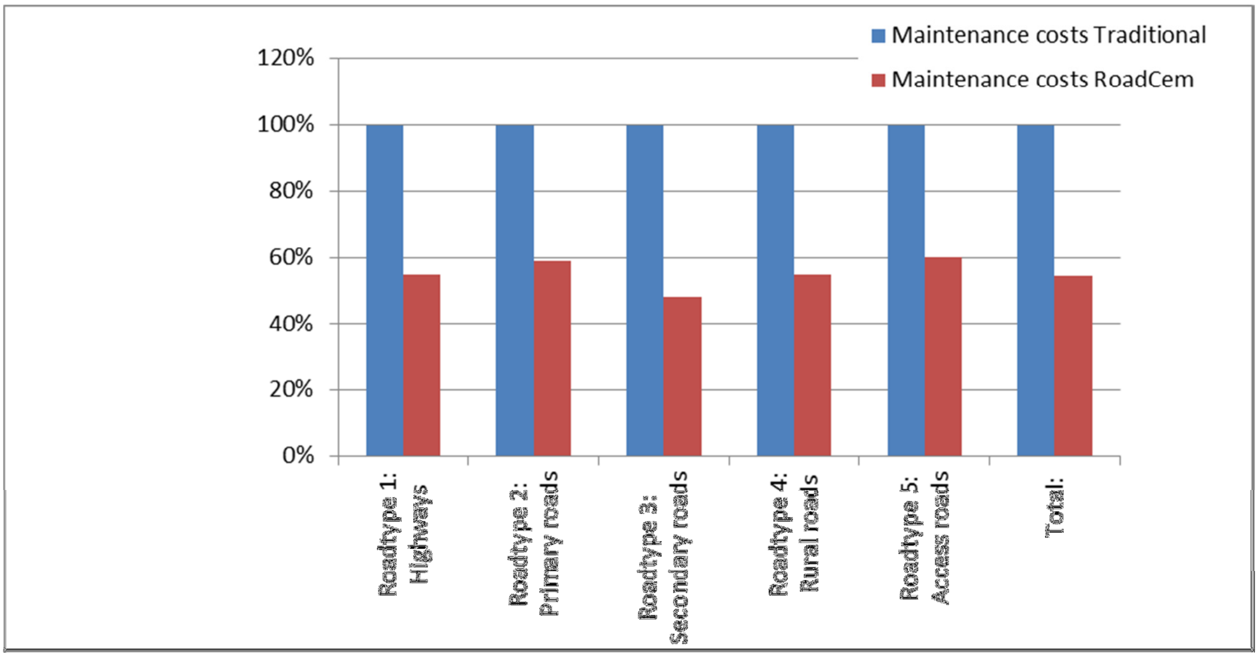


Figure 4.2: Expected maintenance costs due to the floods in the period of 28-06-2012 to 07-05-2012 in percentage to the traditional costs.

These results shown in figure 4.3 are indicative to give an impression of the reconstruction costs for the specific roads. The costs shown in figure 4.3 are based on reconstruction costs of the road. The reconstruction costs for longer damaged parts are higher than for the shorter parts.

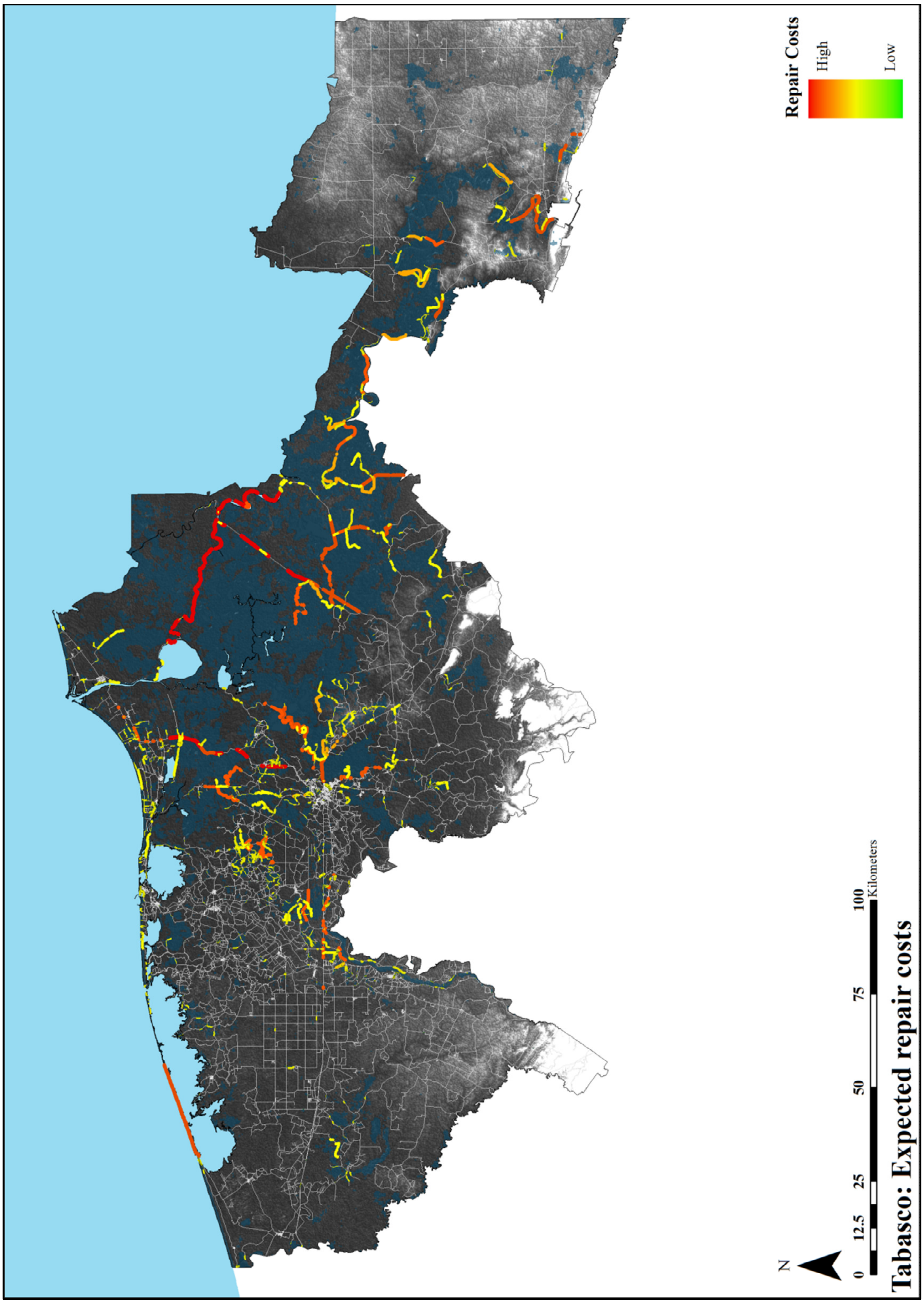


Figure 4.3: Map with an indication of the reconstruction costs of the damaged roads.

4.2.2 Reconstruction of the road network

In this paragraph estimation is made for the time required for the reconstruction works of the damaged roads. The lengths of these damaged roads are normative. On the basis of expert judgment for the traditional reconstruction time is estimated due to the length of the damaged road. The estimations are given in table 4.5.

Length of the damaged road	Expected reconstruction time
1-2 km	4 weeks
2-5 km	6 weeks
5-10 km	8 weeks
10-20 km	10 weeks
15-20 km	20 weeks
20-30 km	25 weeks

Table 4.5: Expected reconstruction time

On the basis of the information in table 4.5, an estimation is made for the reconstruction periods of the flooded road. Figure 4.6 gives an overview of the expected reconstruction time of the flooded roads in the state of Tabasco. Using this map an accurate estimation can be made for the indirect costs in specific regions.
Despite this map not giving hard facts regarding the indirect costs, it gives an impression of the nuisance for the population. This is especially so in areas with a less dense road network where a lengthy blocking of a road will probably give much nuisance to the environment.

The calculation of the reconstruction periods for flooded road segments is not trivial. While assigning single reconstruction periods to inundated road segments is straightforward, the actual interrupted road segments need to be grouped together to reflect the actual progression of repair works; e.g. when 10 small segments within a single road are washed away because of flooding, the repairs will most probably not take place in parallel but rather sequentially. Therefore the reconstruction period of road segments might take longer than the individual flooded portions may require. To overcome this problem, a clustering algorithm is applied that groups road segments within a predefined radius (5km). The assigned reconstruction period is based on the total length of the clustered segments. Note, that within urban centers, road repair works will probably take place in parallel.

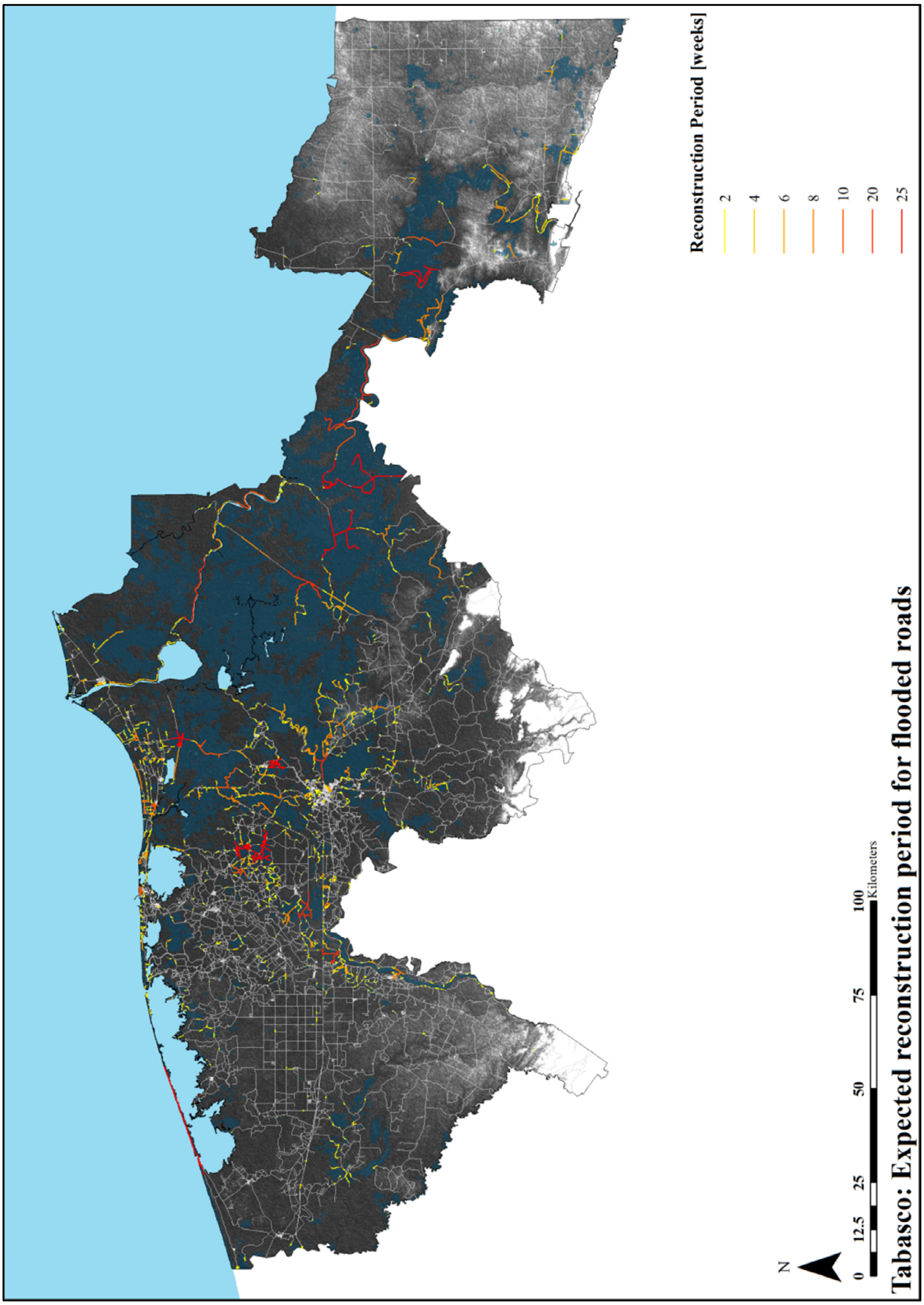


Figure 4.4: Expected reconstruction period for the flooded roads in the period of 28-06-2011 till 07-05-2012

4.2.3 Accessibility of the region

To obtain some insights of the consequences of flooding for the accessibility of individual areas, a road network analysis has been performed on Villahermosa. Using a search algorithm, the maximum extent has been calculated that can be reached from the center of Villahermosa without crossing inundated roads.

The results obtained provide some insights into the effects of traffic interruption as a consequence of flooding.

These results have been set against the calculated extent, during dry conditions within a threshold of 250km (i.e. all areas that can be reached within a 250km boundary using the existing road network).

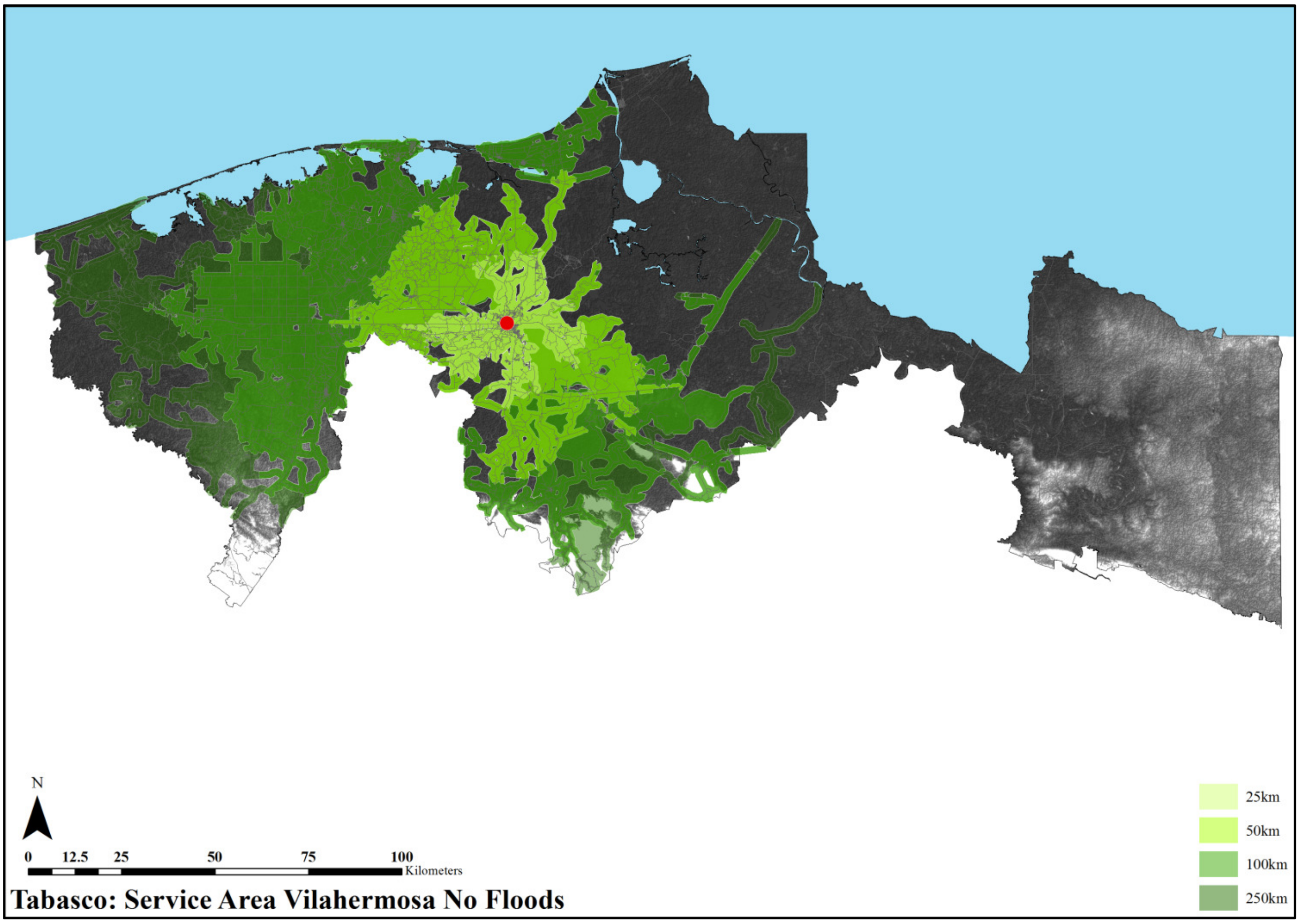


Figure 4.5: Service area Villahermosa dry circumstances

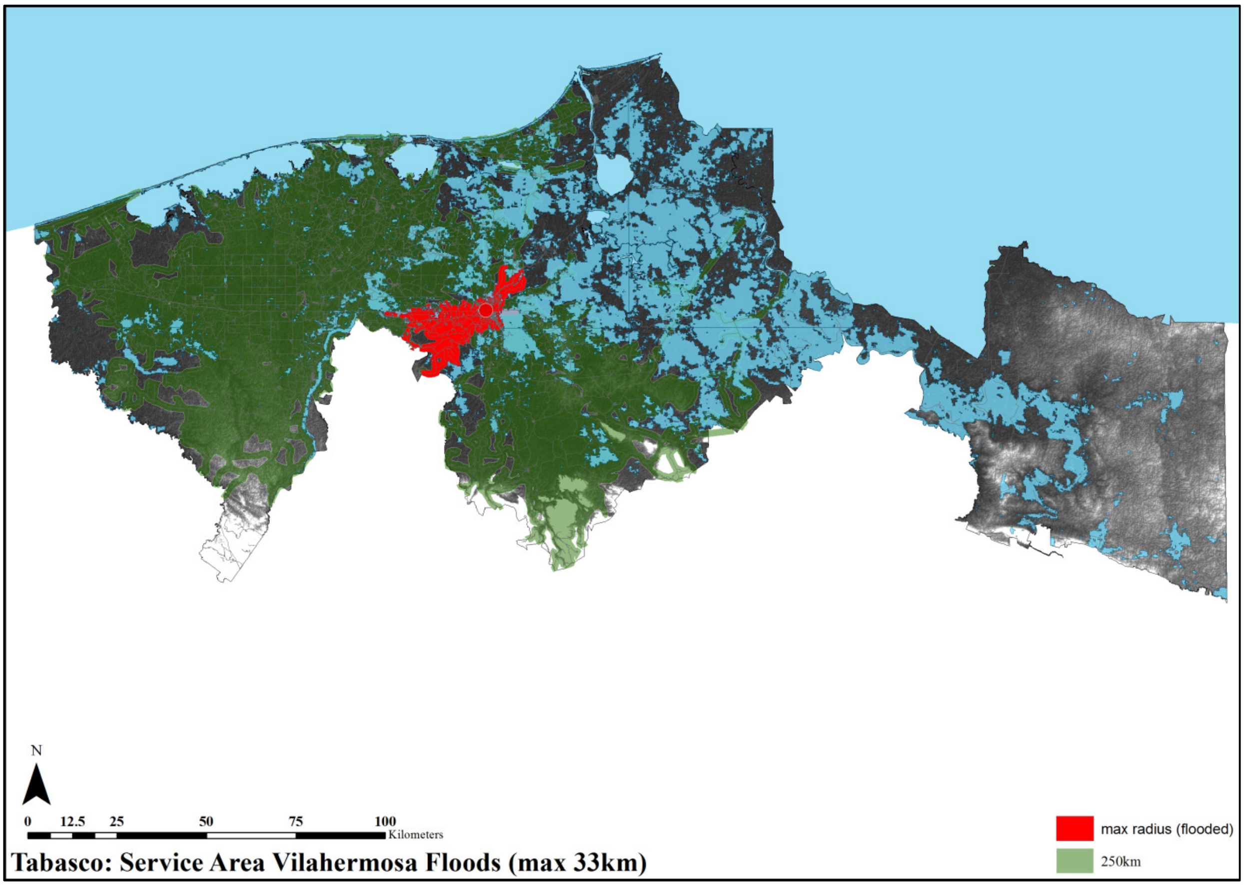


Figure 4.6: Service area Villahermosa during floods

As shown in figure 4.8 is the extent from the center of Villahermosa reduced from >250km to 33 km.

4.2.4 Area with an open road network

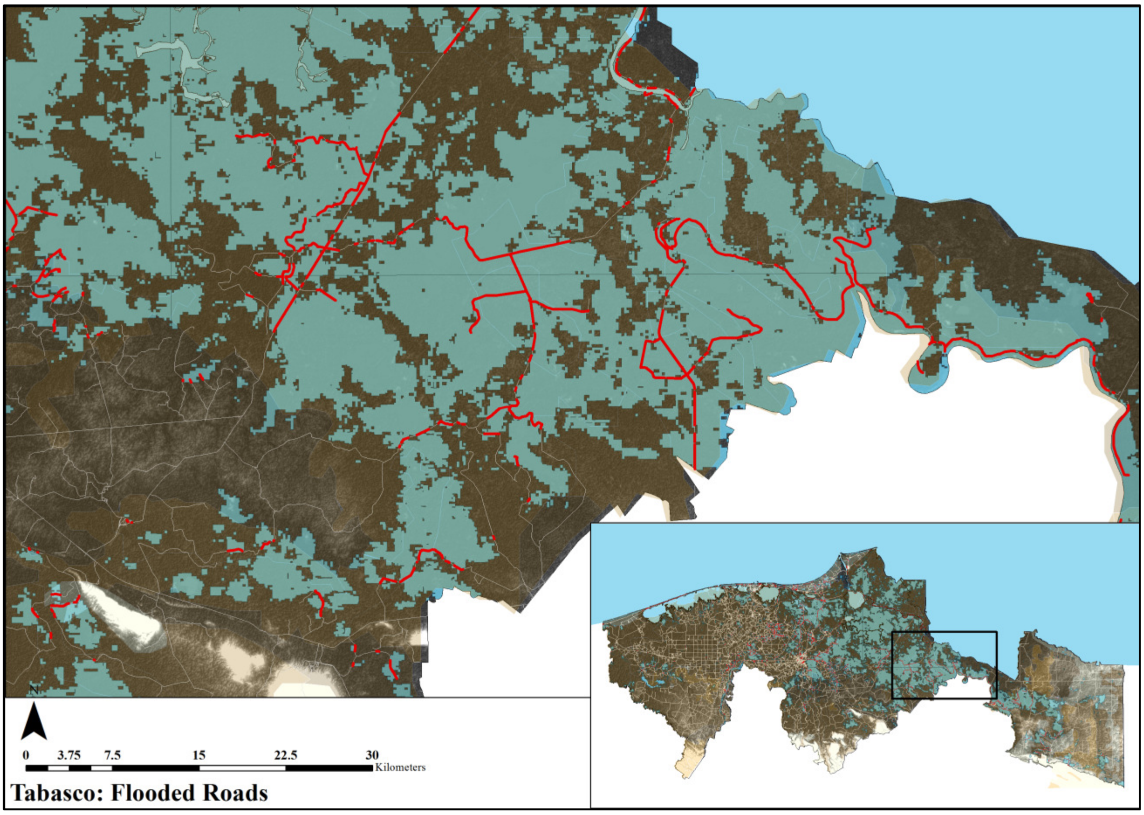


Figure 4.7: Area with an open road network.

In an area where there is an open network the number of roads is small. This means when a road is flooded or damaged, the distance to alternative routes is very large and an area can be cut off from surrounding villages and cities for a period of time. This will lead to high indirect costs, but lower direct costs due to the small amount or roads.

By using PowerCem Technology, the indirect costs will be low. After the floods, the damage on the road infrastructure is minimal. This is because after floods on these roads, that are not damaged, the roads can immediately be opened for use.

With traditional construction techniques the roads will be severely damaged and the reparation time can take up to a few weeks, in which time the road cannot be used.

4.2.5 Area with a dense road network

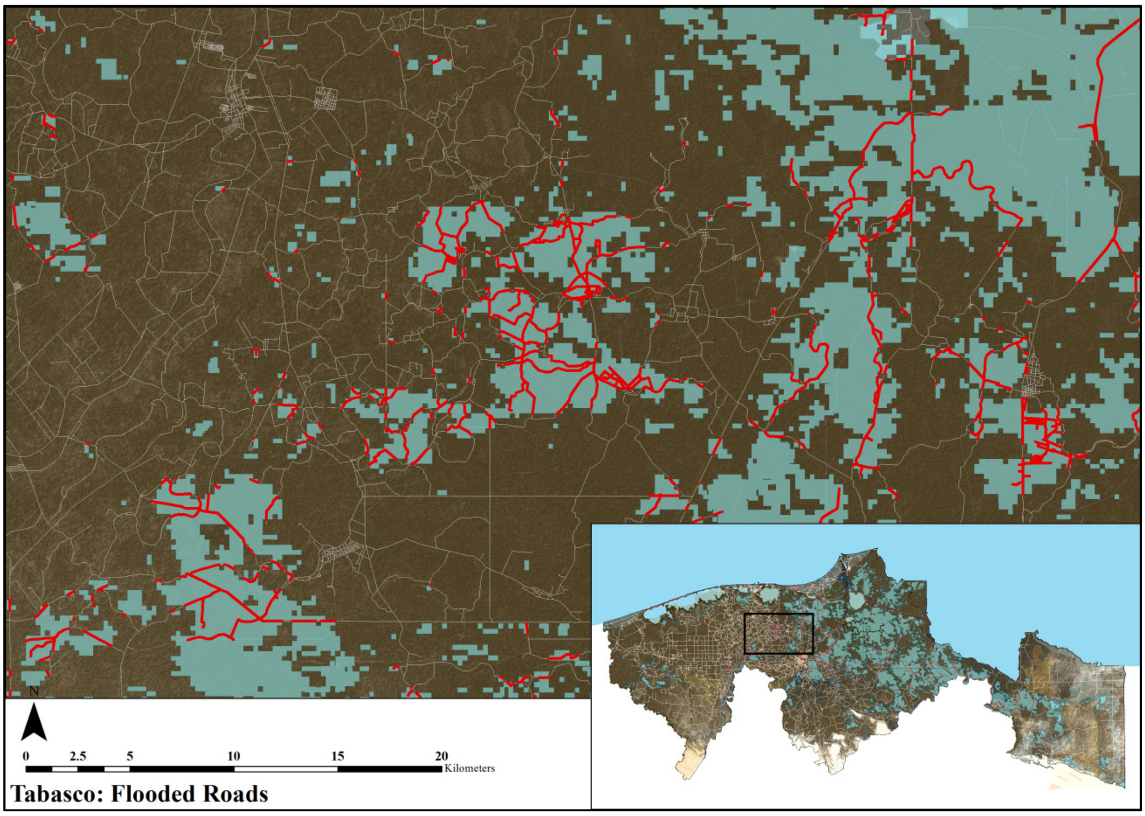


Figure 4.8: Area with a dense road network.

In an area where there is a dense network, the number of roads is large. This means when a road is flooded or damaged, the distance to alternative routes will not be far. An area will be cut off from surrounding villages and cities for a relatively short period of time. This will lead to relatively low indirect costs, but higher direct costs due to the large amount of roads.

By using PowerCem Technology, the direct costs will be low. After the floods, the damage on the road infrastructure is minimal. This is because after floods on these roads, there is no damaged, the roads can immediately be opened for use.

With traditional construction techniques the roads will be severely damaged and the reparation time may take up to a few weeks, in which time the road cannot be used.

4.2.6 City area

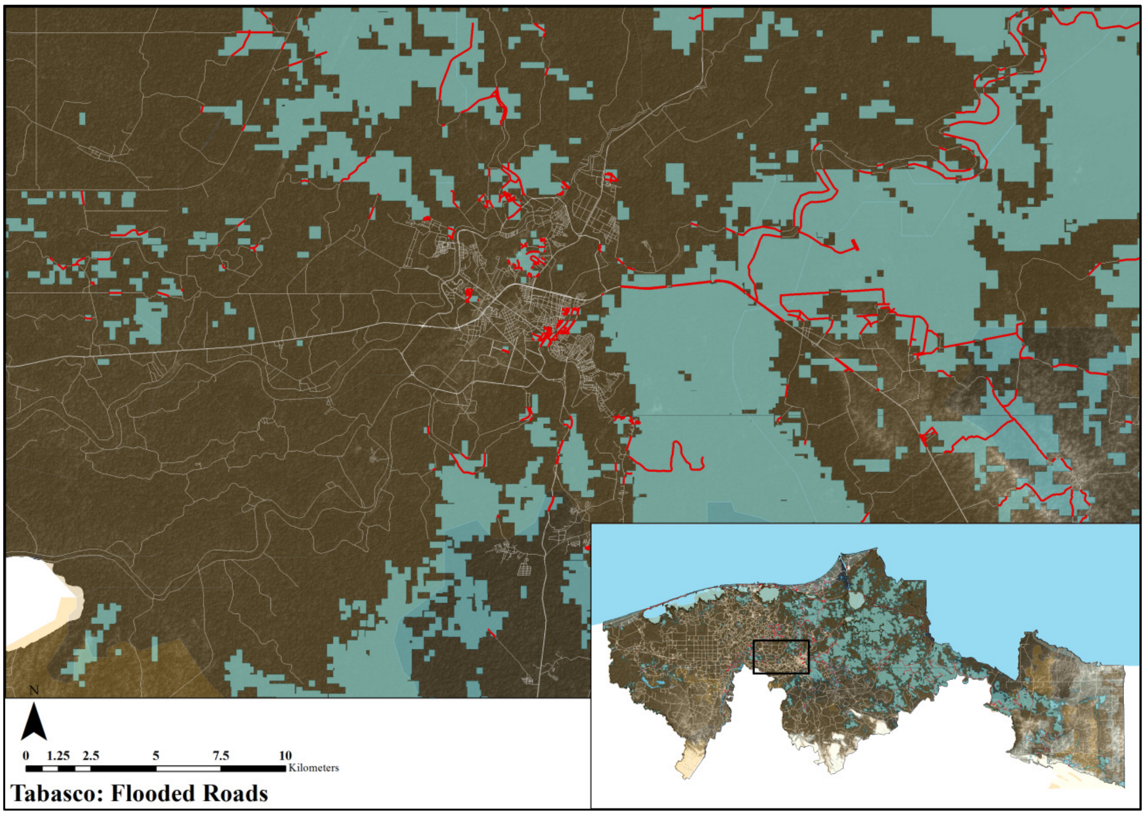


Figure 4.9: Area in city road network.

In an area where there is a dense network like in a city, the number of roads is large. This means when a road is flooded or damaged, the distance to alternative routes in cities is not far, or an area will be cut off from its environs for a relatively short a period. However in a city a lot of economic activities take place and the direct costs are also important values to consider. This will lead to indirect costs, and direct costs due to the large amount or roads.

By using PowerCem Technology, the indirect costs will be low. After the floods, the damage on the road infrastructure is minimal. This is because after floods on these roads, there is no damage, and the roads can immediately be opened for use.

With traditional construction the roads will be severely damaged and the reparation time can take up to a few weeks, in which time the road cannot be used. In a city area this is not desirable.

4.3 Macro-Economic effects in the State Tabasco

To get an accurate impression of the macro-economic effects of the PowerCem technology, the maintenance costs due to flood damages are calculated for a time frame of the design period. The design period is the minimum required lifetime of a road and will be used as criteria for the construction calculations. The design period will be determined depending on the type of road and the location. In this study the design period is fixed for 10 years. Therefore the total costs of a specific road, construction and maintenance costs have to be depreciated over 10 years. After these 10 years the cost cycle will start over again.

To show the economic effects of the PowerCem Technology in flood areas, a comparison is made with traditional systems. In this comparison the maintenance costs for the flood damages are compared. Required maintenance due to the age of the constructions is not included.

The comparison is made over a period of 10 years on the basis of information from the period 28-06-2011to 07-05-2012. It is assumed that the gathered data from this period is normative for 10 years. Since the comparison is based on information from specific years there is for both approaches an outlined scenario. Both scenarios are based on the following assumptions:

- The gathered data regarding the floods and damages given in chapter 3 are normative for a period of 10 years.
- Floods may occur spread over the whole State Tabasco.

Scenario: Reactive policy on the traditional way

In a reactive policy on the traditional method, the destroyed roads will be renewed with the same type of materials used in the original construction. The new construction is calculated for a lifetime of 10 years. However since the traditional constructions are not flood proof the risk of damage due to floods are similar to all the traditional constructions in the state of Tabasco. So this scenario is based on the reasonable assumption that for a period of 10 years a similar amount of roads, spread over the whole country, will be damaged by floods. This means that the maintenance costs due to flood damages are equal for a period of 10 years.

Scenario: Reactive policy with RoadCem

In a reactive policy with RoadCem, will the destroyed roads be renewed on basis of the PowerCem technology? One of the advantages of the PowerCem technology is that the roads built with RoadCem and cement will not be structural damaged by floods.
So after year one (1) is a part of the road network renewed on base of the PowerCem technology. This means that in the second year the amount of damaged roads are expected to lower than in the first year, since part of the roads flooded in the second year have already been replaced with RoadCem. These roads already constructed on basis of the PowerCem technology will not be damaged.
However the roads which are damaged in the second year will be replaced on basis of the PowerCem technology. So after year two even more roads are build flood proof and the expected damage in the third year will be reduced again. Based on expert judgment damage reduction factor is assumed at 20%. This means that after every year the amount of damages will be reduced by 20%.
The proportion of flood proof roads over the reference period is shown in figure 4.5

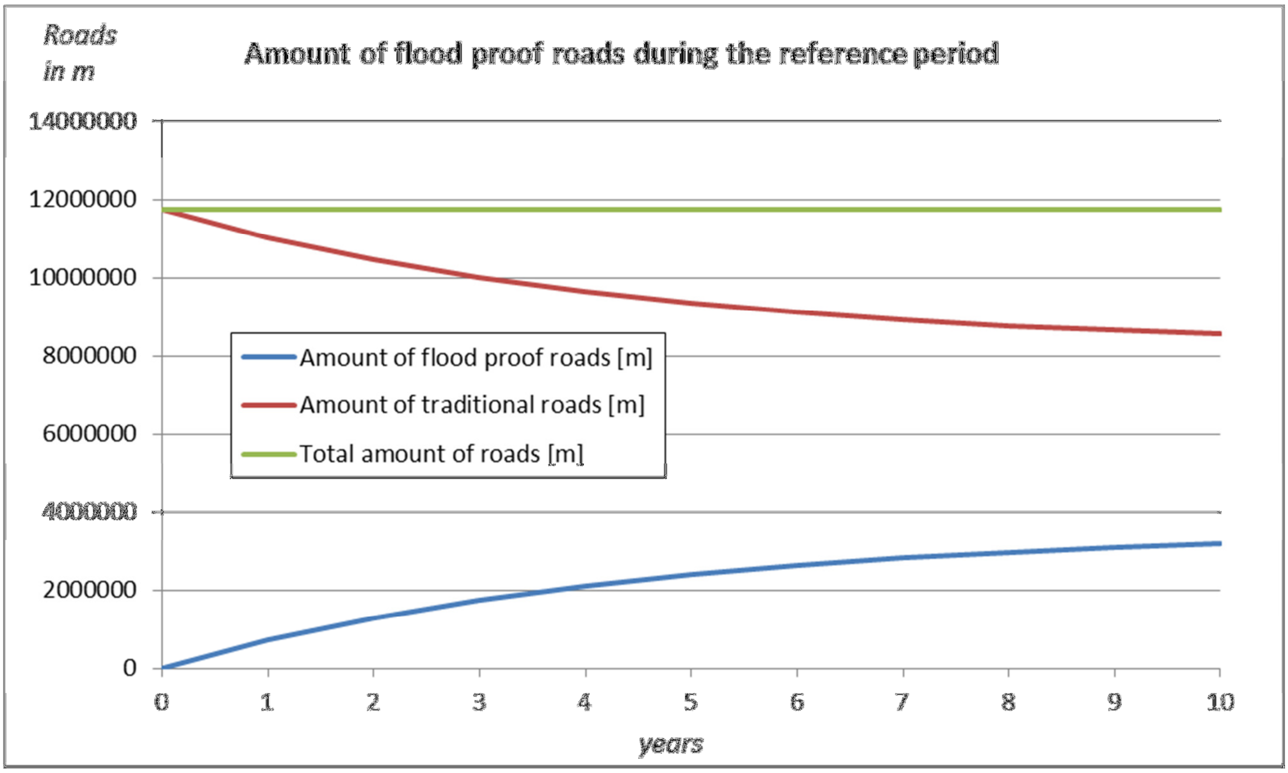


Figure 4.10: Amount flood proof roads given in meters during the reference period

In figure 4.11 are the maintenance costs shown over a reference period of 10 years.

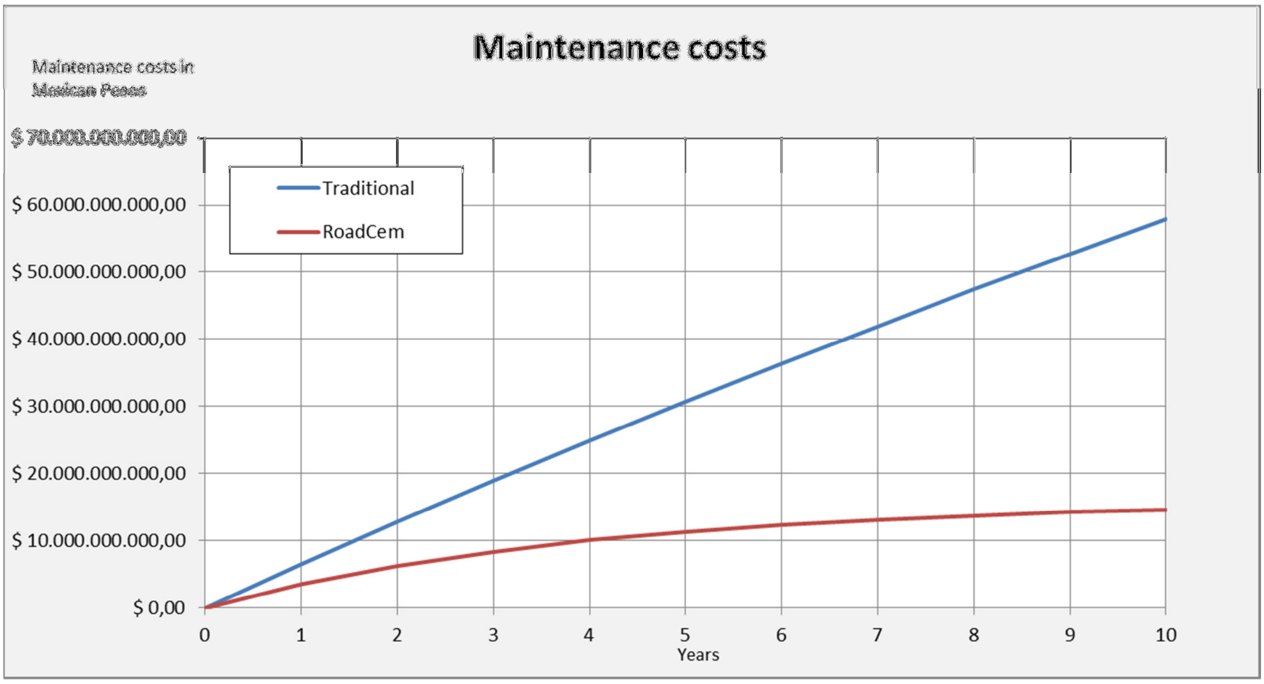


Figure 4.11: Maintenance costs Traditional versus RoadCem

In figure 4.6 it is shown that the PowerCem Technology will offer an enormous economic advantage over a longer term. However these results are based on certain scenarios, the potential will be high. And further research on this subject will be recommended.

4.4 Validation

In the past 5 years a significant number of roads have been constructed on basis of the PowerCem Technology. Parts of these roads are included in the model to give an impression of the costs saved already. In figure 4.12 the roads already constructed on basis of the PowerCem technology are shown in yellow.

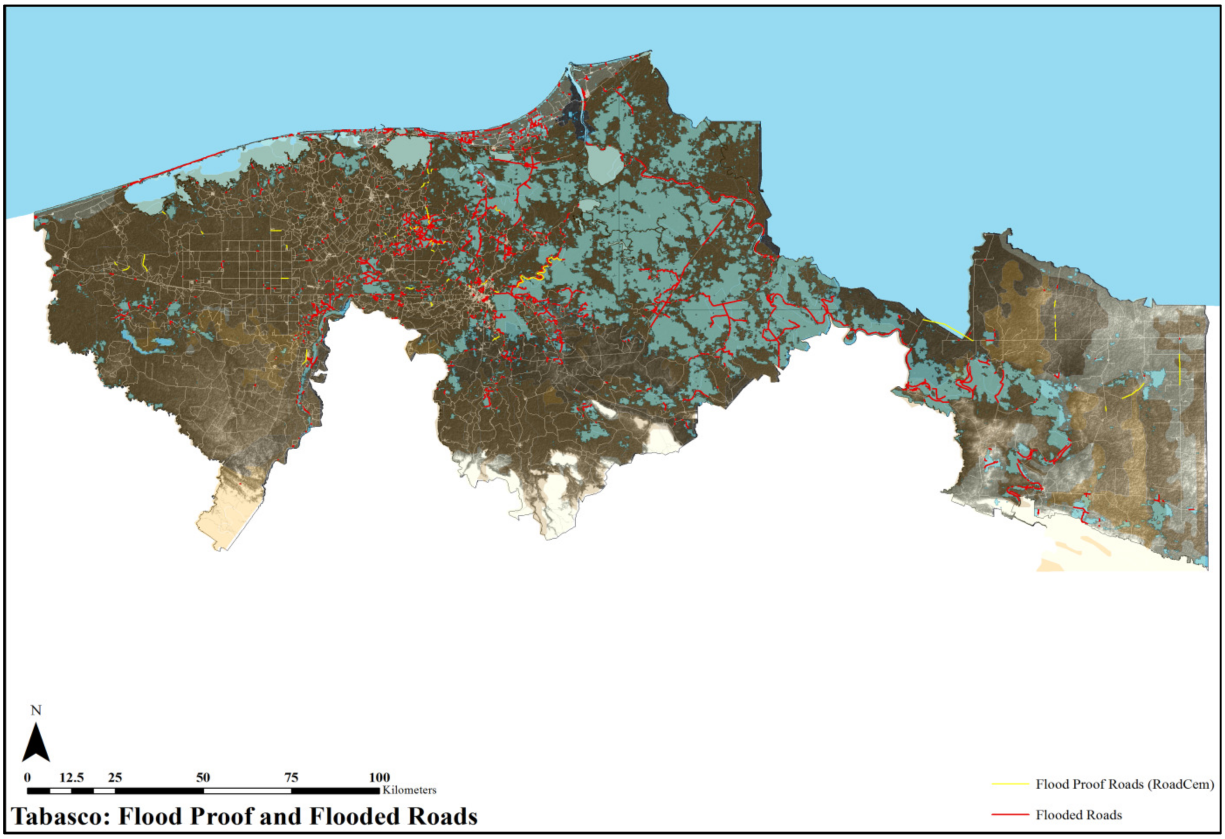


Figure 4.12: Flood extents versus Roads with PowerCem(yellow)

To get an impression of the saving in the reference period of 28-06-2011 to 07-05-2012, the total maintenance costs are determined, assuming that all the flooded roads were also damaged. Next to the total costs the avoided maintenance costs are determined. The avoided maintenance costs are in this case the roads constructed with the PowerCem technology. The results are shown in table 4.6.

	Soil type	Total maintenance costs Costs (peso)	Avoided Costs (Roadcem) Costs (peso)	Net Costs Costs (peso)
Roadtype 1: Highways	Organic Clay	$ 14.980.500,00	$ 0,00	$ 14.980.500,00
	Clay	$ 0,00	$ 0,00	$ 0,00
	Sandy Clay	$ 0,00	$ 0,00	$ 0,00
	Sandy Soil	$ 0,00	$ 0,00	$ 0,00
Roadtype 2: Primary roads	Organic Clay	$ 3.302.777.220,00	$ 0,00	$ 3.302.777.220,00
	Clay	$ 92.921.000,00	$ 0,00	$ 92.921.000,00
	Sandy Clay	$ 0,00	$ 0,00	$ 0,00
	Sandy Soil	$ 197.925.000,00	$ 0,00	$ 197.925.000,00
Roadtype3: Secondary roads	Organic Clay	$ 1.408.933.500,00	$ 11.414.965,00	$ 1.397.518.535,00
	Clay	$ 205.298.000,00	$ 0,00	$ 205.298.000,00
	Sandy Clay	$ 31.123.000,00	$ 0,00	$ 31.123.000,00
	Sandy Soil	$ 24.448.000,00	$ 0,00	$ 24.448.000,00
Roadtype 4: Rural roads	Organic Clay	$ 5.462.799.414,00	$ 124.007.588,25	$ 5.338.791.825,75
	Clay	$ 362.415.716,00	$ 0,00	$ 362.415.716,00
	Sandy Clay	$ 33.904.150,00	$ 0,00	$ 33.904.150,00
	Sandy Soil	$ 709.344.750,00	$ 0,00	$ 709.344.750,00
Roadtype 5: Access roads	Organic Clay	$ 211.094.910,00	$ 0,00	$ 211.094.910,00
	Clay	$ 7.032.300,00	$ 0,00	$ 7.032.300,00
	Sandy Clay	$ 0,00	$ 0,00	$ 0,00
	Sandy Soil	$ 3.990.231,00	$ 0,00	$ 3.990.231,00
Total costs in mexican pesos		**$ 12.068.987.691,00**	**$ 135.422.553,25**	**$ 11.933.565.137,75**

Table 4.6: Avoided costs with RoadCem

Based on the extent of floods of the reference period of 28-06-2011 to 07-05-2012 an amount of $135.422.553 Mexican Pesos has been saved.

5 Conclusions & Recommendations

5.1 General

PowerCem Technologies is a company which offers a technology for infrastructure whereby a highly durable pavement construction will be achieved. Based on experiences these pavement constructions are highly resistant against water erosion. This makes the PowerCem Technology very useful in flood risk areas. The roads can be used directly after a flood to provide the region with food and medical supplies. Also the maintenance costs of the roads after a flood will be reduced to the minimum.

In Tabasco, a state of Mexico, this technology has been used for 3 years now. During these years some floods occurred and the PowerCem Technology based road constructions were not damaged. As such, many parties including governments, engineering companies and contractors are interested in this technology. With the aid of this study the economic value of this technology will be emphasized.

The overall objective is to assess the economic effects of the PowerCem Technology on the infrastructure in flood risk and inundation areas. To determine the economic effects a difference is made in direct costs, e.g. the rehabilitation of a specific damaged road and the indirect costs, e.g. the influence on the accessibility of a region.

The direct economic effects are simulated in a model which has been developed during this study. This study will be validated for a specific region; however the final model must be applicable for world-wide purposes. For the indirect costs the effects are described for three locations.

The economic effects are determined by a comparison between traditional systems and the PowerCem Technology.

The main objective will be answered by the following sub-objectives:

- What are the damages on the road infrastructure after a flood in a specific region?
- What are the damage and maintenance costs of traditional systems?
- What are the costs of the PowerCem Technology?
- What are the technical benefits of the PowerCem Technology in relation to traditional systems?

In paragraph 5.2 the conclusions of this study given and in paragraph 5.3 further recommendations are proposed.

5.2 Conclusions

To determine the macro-economic effects of the PowerCem technology in flood risk areas, PowerCem Technologies in close collaboration with UNESCO-IHE has developed a model wherein with local data as input; accurate output estimations can be made.

The results obtained in this study are based on the extent of floods from the period of 28-06-2011 to 07-05-2012. Based on the extent of these floods, the amount of roads located in the flooded areas are determined.

Type of road		Flooded roads				
		Soil type 1 [m]	Soil type 2 [m]	Soil type 3 [m]	Soil type 4 [m]	**Totals [m]**
Roadtype 1	Highways	3.827	0	0	0	3.827
Roadtype 2	Primary roads	139.008	4.316	0	10.602	153.926
Roadtype 3	Secondary roads	120.790	19.427	3.192	2.667	146.076
Roadtype 4	Rural roads	837.955	64.045	6.767	156.401	1.065.168
Roadtype 5	Access roads	43.802	1.686	0	11.922	57.410
Total		**1.145.382**	**89.474**	**9.959**	**181.592**	**1.426.407**

Table 5.1: Flooded roads based on the flood extents

The location of the flooded roads in the reference period is shown in figure 5.1.

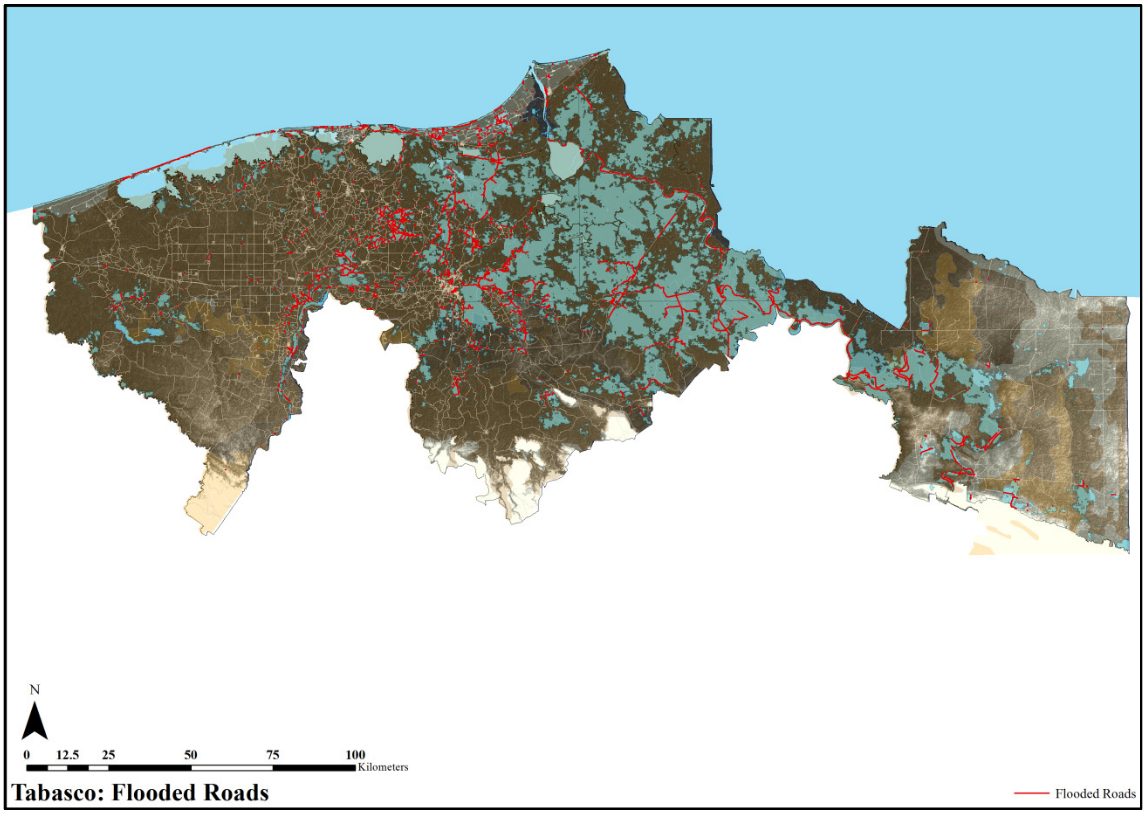


Figure 5.1: Flood extents with road network in the period of 28-06-2011 till 07-05-2012

Not all the roads located in the flooded area will be damaged in the reference period, since roads could be built on dikes or the roads will simply not be damaged. Based on an expert judgment via a percentage of road type, the actual amount of damaged roads can be determined. These results are shown in table 5.2.

Type of road		Assumed amount of damaged roads				
		Soil type 1 [m]	Soil type 2 [m]	Soil type 3 [m]	Soil type 4 [m]	**Totals [m]**
Roadtype 1	Highways	383	0	0	0	383
Roadtype 2	Primary roads	20.851	647	0	1.590	23.089
Roadtype 3	Secondary roads	54.356	8.742	1.436	1.200	65.734
Roadtype 4	Rural roads	460.875	35.225	3.722	86.021	585.842
Roadtype 5	Access roads	28.471	1.096	0	7.749	37.317
Total		**564.936**	**45.710**	**5.158**	**96.560**	**712.365**

Table 5.2: Assumed amount of damaged roads as result of the floods from 28-06-2011 till 07-05-2012

Based on the amount of damaged roads, maintenance costs are determined. To determine the macro-economic effects of the PowerCem technology in flood risk areas the maintenance of the traditional method is compared with the maintenance costs by using the PowerCem Technology. The maintenance costs by the traditional method are summarized in table 5.3, the maintenance costs using the PowerCem technology are summarized in table 5.4.

Type of road		Maintenance costs Traditional				
		Soil type 1 MEXICAN PESOS	Soil type 2 MEXICAN PESOS	Soil type 3 MEXICAN PESOS	Soil type 4 MEXICAN PESOS	**Totals** MEXICAN PESOS
Roadtype 1	Highways	$ 16.542.667,47	$ 0,00	$ 0,00	$ 0,00	$ 16.542.667,47
Roadtype 2	Primary roads	$ 408.161.552,46	$ 12.672.833,65	$ 0,00	$ 29.093.746,98	$ 449.928.133,09
Roadtype 3	Secondary roads	$ 714.917.498,52	$ 114.982.219,09	$ 17.512.985,63	$ 14.632.560,36	$ 862.045.263,60
Roadtype 4	Rural roads	$ 3.892.760.731,16	$ 297.524.164,22	$ 28.656.437,48	$ 662.316.459,09	$ 4.881.257.791,95
Roadtype 5	Access roads	$ 177.112.814,86	$ 6.817.318,98	$ 0,00	$ 43.245.098,55	$ 227.175.232,39
Total		**$ 5.209.495.264,48**	**$ 431.996.535,94**	**$ 46.169.423,11**	**$ 749.287.864,98**	**$ 6.436.949.088,51**

Table 5.3: Maintenance costs using traditional systems

Type of road		Maintenance costs RoadCem				
		Soil type 1 MEXICAN PESOS	Soil type 2 MEXICAN PESOS	Soil type 3 MEXICAN PESOS	Soil type 4 MEXICAN PESOS	**Totals**
Roadtype 1	Highways	$ 9.092.785,67	$ 0,00	$ 0,00	$ 0,00	$ 9.092.785,67
Roadtype 2	Primary roads	$ 243.216.649,04	$ 6.841.213,31	$ 0,00	$ 14.582.117,07	$ 264.639.979,41
Roadtype 3	Secondary roads	$ 354.366.192,07	$ 49.471.371,62	$ 7.196.590,02	$ 5.443.201,45	$ 416.477.355,16
Roadtype 4	Rural roads	$ 2.221.129.843,92	$ 146.873.333,89	$ 13.713.075,12	$ 286.855.829,94	$ 2.668.572.082,86
Roadtype 5	Access roads	$ 111.479.501,13	$ 3.698.952,13	$ 0,00	$ 20.869.388,26	$ 136.047.841,53
Total		**$ 2.939.284.971,82**	**$ 206.884.870,96**	**$ 20.909.665,14**	**$ 327.750.536,71**	**$ 3.494.830.044,63**

Table 5.4: Maintenance costs using the PowerCem technology.

The difference in maintenance costs are shown in figure 5.2.

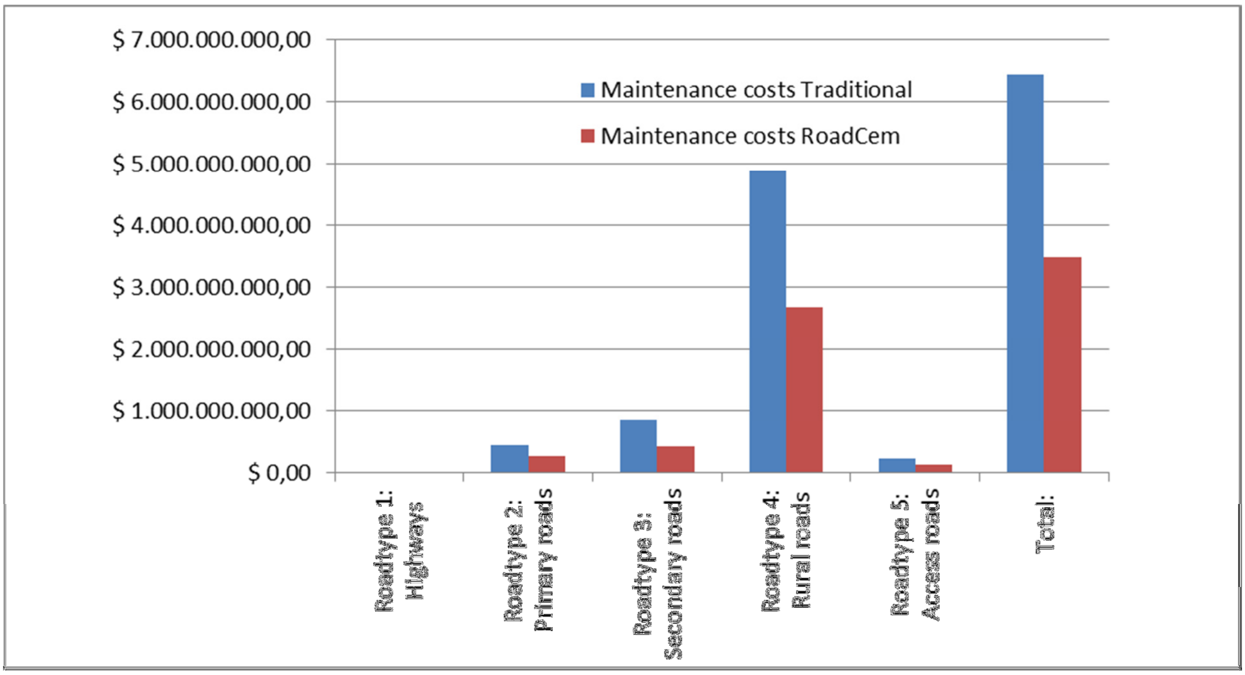


Figure 5.2: Expected maintenance costs due to the floods in the period of 28-06-2012 till 07-05-2012 in Mexican Pesos

As shown in figure 5.2 the maintenance costs with the PowerCem technology in relation to the traditional maintenance reduced by approximately 50%.

To get an accurate impression of the macro-economic effects of the PowerCem technology the maintenance costs due to flood damages are also determined for a longer period of 10 years. Since all the roads in the state Tabasco will be engineered for a lifetime of 10 years, after these 10 years the cost cycle will start over again.

Since the comparison is based on information from a specific year there is for both approaches an outlined scenario. Both scenarios are based on the following assumptions:

- The gathered data regarding the floods and damages given in chapter 3 are normative for a period of 10 years;
- Floods may occur spread over the whole State Tabasco

There are scenario's outlined to compare the traditional maintenance costs and the maintenance cost on basis of the PowerCem Technology

- **Scenario: Reactive policy on the traditional way**
  In a reactive policy on the traditional way will the destroyed roads be renewed with the same materials used in the original construction? This scenario is based on the reasonable assumption that for a period of 10 years a similar amount of roads, spread over the whole country, will be damaged by floods. This means that the maintenance costs due to flood damages are equal for a period of 10 years.
- **Scenario: Reactive policy with RoadCem**
  In a reactive policy with RoadCem will the destroyed roads be renewed on base of the PowerCem technology? One of the advantages of the PowerCem technology is that the roads built with RoadCem and cement will not be structural damaged by floods. Since the growing amount of roads built on the basis of the PowerCem technology the maintenance costs are expected to reduce during this time. Therefore an assumptive reduction percentage of 20% is used.

In figure 5.3 are the maintenance costs shown over a reference period of 10 years.

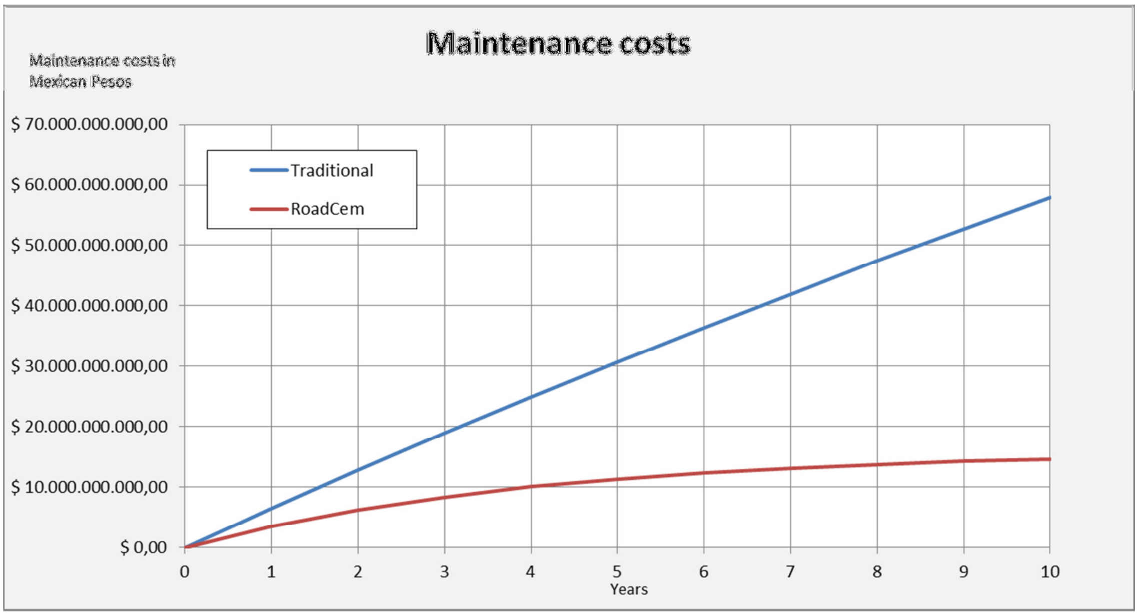


Figure 5.3: *Maintenance costs Traditional vs RoadCem*

In figure 4.6 it is shown that the PowerCem Technology will offer an enormous economic advantage over a longer term. After 1 year the maintenance costs are reduced by 25 % but after a period of 10 years the cost reduction will be approximately 75%. So the potential of the PowerCem technology will be significant especially in the longer term.

Besides the significant advantage for the direct costs the PowerCem technology will also have potentials in the indirect costs. So the road network is more reliable since less traffic blocks occur. Indicative, is shown in figure 5.4 the expected construction time of the roads in Tabasco.

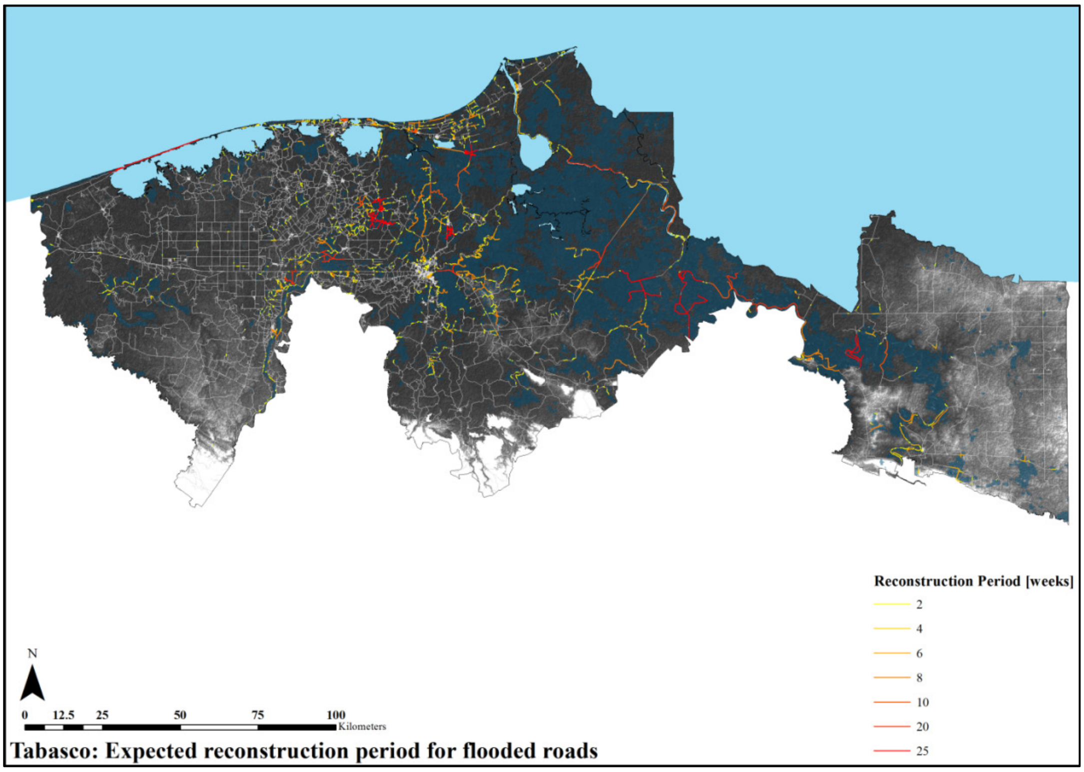


Figure 5.4: Expected reconstruction time

In figure 5.4 it is shown that a signifacant amount of roads will be blocked for quite a long period if they are affected by flooding. If these roads can be protected against damage the nuisance for the environment in the form of the population and industries will be reduced to the minimum.

Based on this study it can be concluded that the PowerCem technology will have a positive influence on the macro-economics in flood risk areas. In this study it is shown that a cost reduction of 50% for the direct costs is not exceptional.

Besides the direct costs, the indirect costs are at least equally important. The indirect costs are more dependent on the specific situation. The indirect costs in sparse areas are mostly low, but in an industrial environment these costs can be expected to be extremely high. A poor accessibility of the road network could even lead to the closure of industries or companies and employment would be reduced.

However, the macro economic effects will be strongly dependent on the local circumstances and the country. It will always be advisable to check the local circumstances before a judgment can be made for the possible savings for companies, entities and governments which are investing in the road infrastructure of the country.

Glossary

Cohesion[1]	Attraction between soil particles (usually fine), by which they are maintained in a fixed mass without the application of external forces.
Collapse[1]	Occurrence of inadmissible large deformations of a structure, such that it loses coherence
Correlation[1]	Measure of the extent to which a change in one variable tends to correspond to a change in another variable. One measure of linear dependence in the correlation coefficient.
Cracking[1]	Loss of coherence for layer or element intended to be coherent.
Dependence[1]	Extent to which one variable depends on another variable. Dependence affects the likelihood of two or more thresholds being exceeded simultaneously. When it is not known whether dependence exists between two variables or parameters, guidance on the importance of any assumption can be provided by assessing the fully dependent and independent cases (correlation).
Deterministic process[1]	Method or process that adopts precise, single values for all variables and input values, giving a single value output.
Discount rate[3]	Represents the opportunity costs associated with the investment available in other (public) projects. This can be different for different infrastructure sectors.
Embankment[1]	Bank formed artificially from (usually local) materials to exclude water from a given area. The main embankment structure provides mass obstruction against water. The embankment "outward face" is exposed directly to water, and the "inward face" is on the landward side and hence not normally exposed directly to water. The "embankment crest" is the top of the embankment, typically flat and (ideally) several meters wide.
Erosion[1]	Processes of wearing a way of land or defense surface by mechanical action (e.g. water, wind, ice)
Failure[1]	Inability to achieve a defined performance threshold (response given loading). "Catastrophic" failure describes the situation where the consequences are immediate and severe, whereas "prognostic" failure describes the situation where the consequences only grow to a significant level when additional loading has been applied and/or time has elapsed.
Failure cause[1]	Reason why a component fails
Failure mechanism[1]	The way in which a structure collapses (shearing, piping, erosion), or fails to retain water (flood defense failure mechanism).
Flood[1]	A temporary covering of land by water outside its normal confines.

Flood control[1]	A structural intervention to limit flooding and so an example of a risk management structure.
Flood damage[1]	Damage to receptors (buildings, infrastructure, goods), production and intangibles (life, cultural and ecological assets) caused by a flood.
Flood hazard map[1]	Map with the predicted or documented extent of flooding, with or without an indication of the flood probability.
Flood level[1]	Water level during a flood.
Flood peak[1]	Highest water level recorded in a river during a flood.
Flooding system[1]	In the broadest terms, a system may be described as the social and physical domain within which risks arise and are managed. An understanding of the way of a system behaves and, in particular, the mechanism by which it may fail, is an essential aspect of understanding risk. This is true for an organizational system like flood warning, as well as for a more physical system, such as a series of flood defenses protecting a flood plain.
Inundation[1]	Deliberate of flooding of land with water.
Joint probability[1]	The probability of specific values of one or more variables occurring simultaneously. For example, extreme water levels in estuaries may occur at times of high river flow, times of high sea level or times when both river flow and sea level are above average levels. When assessing the likelihood of occurrence of high estuarine water levels it is therefore necessary to consider the joint probability of high river flows and high sea levels.
Judgement[1]	Decisions taken arising from the critical assessment of the relevant knowledge.
Knowledge[1]	Spectrum of known relevant information.
Knowledge uncertainty[1]	Uncertainty due to lack of knowledge of all the causes and effects in a physical or social system. For example, a numerical model of wave transformation may not include an accurate mathematical description of all the relevant physical processes. Wave breaking aspects may be parameterized to compensate for the lack of knowledge regarding the physics. The model is thus subject to a form of knowledge uncertainty. Various forms of knowledge uncertainty exist, such as: Process model uncertainty, statistical inference uncertainty and statistical model uncertainty.
Macroeconomic model[2]	A macroeconomic model is a deliberate simplification of actual infrastructure spending. It is possible to study all the infrastructure projects in elaborate detail, for example by looking at the spending patterns over every year of every project and then draw conclusions from masses of detail. The result would be a nightmare, time-wasting and ineffective; one would simply not see the wood for the trees. Instead, a macroeconomic model focuses on key elements that are relevant to the problem under investigation. The main goals of a macroeconomic policy are, in essence, the long-term impacts of the infrastructure on the government's budget.
Monetary assessment method[3]	Like "cost-benefit analysis" and "cost effectiveness analysis", this method assumes that effect scan be quantified in

	monetary terms; This requirement does not hold for non-monetary methods and different sorts of effects are then aggregated according to standardization procedures to produce a more or less explicit standardization.
Monte Carlo simulation[1]	Level III probabilistic calculation method where a large number of simulations are performed. In each simulation, numbers are drawn randomly from the distribution functions associated with the parameters in the strength and loading models, subsequently the value of the limit state function is calculated for the joint draw. The number of times that Z is smaller than zero is divided by the total number of simulations to estimate the total probability of failure.
Multi-criteria Evaluation method[3]	Embraces a number of methods; This not illustrates a representative set of methods, including “weighted sums”, “characteristic value method (Eigenvalue method)”, “permutation method”, “concordance method”, and “multidimensional scaling method”.
Opportunity cost[3]	Benefits associated with the best alternative on offer (missed opportunity); given perfect competition (maximum effectiveness), every good or service would be used in such a way that its value is greater than or equal to its opportunity cost.
Overflowing[1]	Water flow over the crest own of the defense because the water level in front is higher than the defense crown or crest.
Participation methods[3]	Including “goal fabric analysis”, these are concerned to involve the interested parties as closely as possible in the decision making.
Process model uncertainty[1]	All models are an abstraction of reality and can never be considered true. They are thus subject to process model uncertainty. Measured data versus modeled data comparisons give an insight into the extent of model uncertainty but do not produce a complete picture.
Resilience[1]	Ability of a system or defense to react to and recover from the damaging effect of realized hazards.
Resistance[1]	The ability of a system to remain unchanged by external events.
Risk[1]	Risk is a functional of probability, exposure and vulnerability. Often, in practice, exposure is incorporated in the assessment of consequences, therefore risk can be considered as having two components, the probability that an event will occur and the impact (or consequence) associated with that event.
Risk analyses[1]	A methodology to objectively determine risk by analyzing and combining probabilities and consequences.
Risk mapping[1]	The process of establishing the spatial extent of risk (combining information on probability and consequences). Risk mapping requires combining maps of hazards and vulnerabilities. The results of these analyses are usually presented in the form of maps that show the magnitude and nature of the risk.
Scenario[1]	A plausible description of a situation, based on a coherent and internally consistent set of assumptions. Scenarios are neither

	predictions nor forecasts. The results of scenarios (unlike forecasts) depend on the boundary conditions of the scenario.
Sensitivity[1]	Refers to either: the resilience of a particular receptor to a given hazard. For example, frequent sea water flooding may have considerably greater impact on a fresh water habitat, than a brackish lagoon; or: the change in a result or conclusion arising from a specific perturbation in input values or assumptions.
Sensitivity Analyses[1]	The identification at the beginning of the appraisal of those parameters which critically affect the choice between the identified alternative course of action.
Shadow pricing[3]	Corrected price: for example, when the price of the labor decreases by 50 percent when unemployment is high.
Statistical inference y uncertainty[1]	Formal quantification of the uncertainty of estimating the population from a sample. The uncertainty is related to the extent of data and variability of the data that make up the sample.
Statistical model uncertainty[1]	Uncertainty associated with the fitting of a statistical model. The statistical model is usually assumed to be correct. However, if two different models fit a set of data equally well but have different extrapolations/interpolations then this assumption is not valid and there is statistical model uncertainty.
Summary table method[3]	This includes the “planning balance sheet”, “goals achievement matrix” and “score map methods”.
System[1]	An assembly of elements, and the interconnections between these elements, constituting a whole and generally characteristic by its behavior.
Uncertainty[1]	A general concept that reflects our lack of sureness about someone or something, ranging from just short of complete sureness to an almost complete lack of conviction about an outcome.
Validation[1]	Is the process of comparing model output with observations of the ‘real world’.
Variability[1]	The change over time of the value or state of some parameter or system or element where this change may be systemic, cyclical or exhibit no apparent pattern.
Variable – nominal[3]	The variables with a nominal scale have only an identity characteristic: for example, soil types like clay, sand, gravel, silt etc.
Variable- ordinal[3]	Ordinal variables have an identity characteristic as well as a ranking without a fixed value scale.
Variable- interval[3]	This variable has an identity characteristic, a ranking value, and a fixed measurement: for example, a temperature expressed in degrees Celsius.
Variable- ratio[3]	This variable has an identity characteristic, a ranking value, a fixed measurement and a fixed “zero” point.
Verification[3]	Is the process of checking the values of the variables that are used as input values for the calculation or simulation for a

	system or model. Therefore a check of the units, sources and requirements are essential.
Vulnerability[1]	Characteristic of a system that describes its potential to be harmed. This can be considered as a combination of susceptibility and value.

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Appendix 1: Statement of SCT

SECRETARÍA DE
COMUNICACIONES
Y TRANSPORTES

"2010, Año de la Patria, Bicentenario del Inicio de la Independencia y Centenario de la Revolución"

Oficio No. 3.1.101.102/2010

Dirección General de Carreteras
Coordinación de Proyectos y Supervisión de Carreteras Federales

A QUIEN CORRESPONDA:

México, D. F. 14 de septiembre de 2010.

Por medio de la presente y en relación al producto estabilizador denominado RoadCem de la empresa PowerCem, le manifiesto que se han obtenido excelentes resultados en diversas obras a nivel nacional, cumpliendo y superando satisfactoriamente con las resistencias y pruebas de laboratorio y campo que demandaban las especificaciones de los proyectos.

Además de hacer mención de que se obtuvieron ahorros sustanciales en costos y tiempos de elaboración al aplicar dicho producto en las obras.

Por lo tanto recomendamos ampliamente su aplicación en las obras en todo el territorio nacional.

Aprovecho la oportunidad para enviarle un cordial saludo.

Atentamente

Ing. José María Fimbres Castillo
Coordinación de Proyectos y
Supervisión de Carreteras Federales

c.c.p. Ing. Augusto Bello Vargas, Director Técnico, Presente.
c.c.p. Ing. Salvador Fernández Ayala, Director de Obras, Presente
c.c.p. Archivo de la Coordinación de Proyecto y Supervisión de Carreteras Federales

JMFC'prg

Minister of Communication and transports.

Letter no. 3.1.101.102/2010

General Direction of Roads.
Coordination of Project and Supervision of Federal Highways.

TO WHOM IT MAY CONCERN:

México City, September 14, 2010.

Through this and in relation with the stabilization product called RoadCem from the company PowerCem, I express that we found that excellent results have been obtained in various works at the national level, successfully meeting and exceeding the resistance and laboratory and field tests that the specifications projects demands.

Besides I want to mention that we obtained substantial cost and time savings when applying the product in the works.

Therefore, we strongly recommend its application in the works throughout the country.

I take this opportunity to send a cordial greeting.

Carefully,

Ing. Jose María Fimbres Castillo.
Project Coordination and Supervision of Federal Highways.

Appendix 2: Soil classifications of Tabasco

Acrisols

<u>Origin:</u>

Product of the weathering of the acid rocks, the acrisols are acid soils, heavily weathered with low saturation of the base in some depth.

The acrisols show a marked clay accumulation horizon and a low saturation of the bases (less than 50%). These are soils with higher clay content in the subsoil which in surface soil as a result of pedogenetic processes (especially clay migration).

<u>Environment:</u>

Mainly old surfaces with topography with hills or hollows. Regions with a humid tropical/monsoonal, subtropical and warm temperate. The type of natural vegetation in these soils is jungle.

Regional distribution of Acrisols: The acrisols are found in humid tropical regions, humid subtropical and temperate warm. There are about 1.000 million hectares of Acrisols worldwide.

<u>Comparison:</u>

By origin, environment and geographical distribution, the acrisols belong to groups of clays, the primary (source) and secondary (migratory). In both cases the particle diameter is less than 0.002 mm.

Therefore, acrisols are defined in any of the following groups for the Unified Soil Classification System (USCS):

- CH - Inorganic clays of high plasticity, frank clays.
- OH - Organic clays of medium or high plasticity.
- PT - Peat and other highly organic soils.

Arenosols

<u>Origin:</u>

The arenosols not distinguish the horizons of the soil profile and consist entirely of material or coarse sandy loam. Basically there are unconsolidated deposits of sand dunes frequently found in dunes and also in areas of very thick parent material subject to millions of years of weathering.

<u>Environment:</u>

They are found worldwide and are especially abundant in the deserts and in some humid regions. Have very low water retention capacity, because the sand in the soil is not graded, so that is not grain size variations. In humid environments tend to be very acidic, but not in arid climates.

Comparison:

The arenosols are definitely sandy soils, highly siliceous and very poor in nutrients. Because of these properties the arenosols are defined within any of the following groups of the Unified Soil Classification System Classification:

- SP - Sands poorly graded with little or no fines
- SM - Salty sands mixed of sand and silt.

Cambisols

Origin:

Are composed of media parent materials and of finely textured and non-migrants, so, they are originate and evolve in the same place derived from various kinds of rocks. Most are from colluvial deposits accumulation by gravitational processes, for example: slopes), alluvial (associated with large rivers with silt grading to gravel) and wind (associated with wind erosion: sand and silt).

Environment:

Flat to mountain terrains in all climates and under a wide range of vegetation types, with no appreciable amounts of "iluviada" clay (accumulation in a horizon of the soil of elements from other) organic matter, aluminum and/or iron compounds.

Comparison:

Because the grading of these soils ranges goes from gravel to silt, their classification in the USCS is located in the following groups:

- GW - Gravel well graded, sand and gravel mixtures with little or no fines
- GM - Silty gravels, mixtures of gravel, sand and silt
- SW - Well graded Sand, sand and gravel, with little or no fines
- SM - Silty sands, mixed sand and silt.
- ML - Inorganic silts, rock dust, clayey slightly sandy silt or plastics.

Ferralsols

Origin:

Ferralsols represent the classical soil and are often associated with Acrisols. Stem from the decomposition of the silicates by strong weathering of basic rocks. They are red or yellow soils of the humid tropics. These soils are formed by sets of clays dominated by a low activity clays (mainly kaolinite) and high content of sesquioxides.

Environment:

Ferralsols are restricted to regions with basic rocks easily weatherables and a warm and humid weather, typical of flat to undulating lands of humid tropics. Usually has much natural vegetation typical of the tropics, whatever the nutrients are taken up by the roots at a depth and are eventually returned to the soil surface with leaves and other plant debris that falling so are typifies as infertile because of its lack of organic materials and the complete absence of soluble minerals, washed or leached to lower horizons by very wet weather.

Comparison:

The Ferrasoles correspond to a wide range of particle size and its organic content depends on the plant material deposits that falling on its surface. Thus, in the sense of the use of a surface, its USCS nomenclature corresponds to the following groups:

- OL - Organic silts and organic silty clays of low plasticity.
- OH - Organic clays of medium or high plasticity, organic silts with medium plasticity.

And in the deeper layers (> 50cm):

- CL - Inorganic clays of low to medium plasticity sandy clay, silty or poor.
- MH - Inorganic silts, micaceous or diatomaceous silts, more elastic.
- CH - Inorganic clays of high plasticity frank clays.

Fluvisols

Origin:
The Fluvisols are soils developed in alluvial deposits (river, lakes and marines) that accommodate genetically young azonal soils.

Environment:
Observed in alluvial plains, river deltas, valleys and coastal marshes in all climate zones, particularly in the tropics. Many fluvisols under natural conditions are periodically flooded. Most of the Fluvisols have a good natural fertility: lowland rice cultivation is widespread in tropical Fluvisols with satisfactory irrigation and drainage. In dry periods is also stimulated microbial activity that promotes the mineralization of organic material.

Comparison:
In its migratory origin because the water flows that move their water-bearing components to a alluvial deposits, we see the formation of material with low particle size that falls into the range of clays and silts with a little or any amount of sand, because of this, we classify them in the USCS within these groups.

- SP - Sands poorly graded sand with gravel, with little or no fines.
- SC - Sands clay, sand and clay mixtures.
- OL - Organic silts and organic silty clays of low plasticity.
- OH - Organic clays of medium or high plasticity, organic silts medium plasticity.
- PT - Peat and other highly organic soils.

Gleysols

Origin:
Gleysols are soils of a wide range of unconsolidated materials, mainly fluvial, marine and lake, with basic to acidic mineralogy.

Environment:
Tropical soils with clear signs of influence of groundwater that is saturated with water for long periods. They are found in depressed areas and low landscape positions with shallow groundwater.

Comparison:
In addition to their organic quality, the textures of the Gleysols are sandy and loamy and sometimes clay, so they are defined as:

- OL - Organic silts and organic silty clays of low plasticity.
- OH - Organic clays of medium or high plasticity, organic silts medium plasticity.
- PT - Peat and other highly organic soils.

Histosols

Origin:

Most of the Histosols are generated by chemical-biological phenomena under conditions of hydromorphic, a permanent or temporary state of saturation of water in the soil that is associated with the existence of reducing conditions. Histosols comprise soils characterized by being highly organic, even peaty with frequent water logging and nature devoid of oxygen.

Environment:

Are limited to poorly drained basins, depressions, swamps and wetlands with shallow water and highland areas with a high ratio of precipitation/evapotranspiration.

Comparison:

The mineral fraction of these soils is minor compared with that provided by the necromass.

PT - Peat and other highly organic soils.

Leptosols

Origin:

Because these soils are begun to be altered by the action of climate and vegetation, many of its properties are associated with rocks that it originated them and therefore are very varied. Consist of several types of continuous rock or unconsolidated material, less than 20 percent (by volume) of fine soil.

Environment:

They are found mainly in lands with medium or high altitude with strongly dissected topography. Leptosols are found in all climate zones, particularly in areas with heavily eroded.

Comparison:

Leptosols are extremely young and thin soils, very rocky with abundant gravels. Therefore, they can be compared with the following groups:

GW - Gravel well graduates, sand and gravel mixtures with little or no fines

GP - Poorly graded gravels, sand and gravel mixtures with little or no fines

GM - Silty gravels, mixtures of gravel, sand and silt

GC - Clayey gravels, mixtures of gravel, sand and clay

Luvisols

Origin:

They come from a wide variety of unconsolidated materials including extremely heterogeneous sediments of glacial origin and eolian deposits, alluvial and colluvial. Differentiation of pedogenic clay content with a low content in surface soil and a higher content in the subsoil without advanced weathering of high-activity clays.

Environment:

Mostly flat or gently sloping lands, mountainous terrain, undulating plateaus, cool and warm temperate regions with pronounced dry and wet seasons.

Comparison:

Luvisols are soils with higher clay content in the subsoil than in surface soil, so they fall within the clay groups:

- SC - Sand clay, sand and clay mixtures.
- GC - Clayey gravels, mixtures of gravel, sand and clay
- CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, clays poor.

Plinthosols

Origin:

They are mineral soils of warm regions without human influence in their genesis and low activity clays. Are soils with plinthite. The plinthite is more common in material weathered from basic rocks in acidic weathering of rocks. In any case, it is crucial that sufficient iron was present, originating from either the parent material itself or incorporated by filtration of water or groundwater upward from somewhere else. A high proportion is ferruginous of red clay brick color.

Environment:

The formation of plinthite is associated with flat to gently sloping areas with fluctuating groundwater or stagnating surface water. A widely accepted concept is that plinthite is associated with areas of rainforest.

Comparison:

The major fraction of this type of soil rests in the group of clays.

- CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, clays poor.
- CH - Inorganic clays of high plasticity frank clays.

Solonchaks

Origin:

The original material that forms these kinds of soils it is virtually any unconsolidated material. Are soils that have high concentration of soluble salts in some time of the year, with a vegetation of grasses and/or salt-resistant grasses.

Environment:

Solonchaks are distributed in saline coastal plains associated with marshes, deltas, beaches and bars, also in vessels lakes and desert plains.

Comparison:

Due to the biotic environment where they develop, these kinds of soils often hold elements from organic decomposition.

- OL - Organic silts and organic silty clays of low plasticity.
- OH - Organic clays of medium or high plasticity, organic silts medium plasticity.
- PT - Peat and other highly organic soils.

Vertisols

Origin:

Sediments that contains high proportion of swelling clays or swelling clays produced by newly formed from weathering of rocks.

Environment:

These soils are characteristic of the settling basins and swamps in the plains and alluvial valleys, mainly in tropical, subtropical, semiarid to subhumid and humid climates with clear alternation of dry and wet season. The climax vegetation is savannah grassland and/or forest.

Comparison:

Because the major fraction of these soils are clays, these soils fall under the classification of the following groups:

- CH - Inorganic clays of high plasticity frank clays.
- OH - Organic clays of medium or high plasticity, organic silts medium plasticity.

Effect of the action of rivers, the territory of Tabasco, is composed mainly of low plains and wet of alluvial origin. The soil formation is due mostly to migration of particles weathered by aquifer media. Added to this, Tabasco shows a biome very abundant in flora and fauna with a humid tropical climate.

All this defines the characteristics of soils of the State of Tabasco as silty and clay soils that are not entirely suitable for the construction, with traditional systems, of structural elements, such as roads, so it needs new technologies such as the formation of zeolite concretes, in order to achieve these soils from becoming structurally unfit for use.

Appendix 3: Pavement calculation for roads on base of a traditional construction

Calculations traditional constructions:

Soiltype 1 Edyn: 25 Mpa

Project number: Unesco - Floods Tabasco
Date: 5-12-2011
By: Pascal Lakerveld

[yellow] = invullen

Assumptions		
Design lifespan	10	years
Type of vehicle	Vrachtwagen	
Axle configuration	dubbel lucht	
Tire pressure	0,577	MPa
Standard axle load	80	KN
Amount of working days	270	days
Vehicle damage factor	1,9	
Growth per year	2%	
Lane correction factor	1	1;0,95;0,9
Width tire factor	40	1,8 (bij asfalt < 150 mm)
speed of traffic	80	
reliability factor fatique relation sub	85%	1,037

Traffic class	amount of traffic day	lifetime	Sand Edyn	[m]	base coarse Edyn	[m]	topbase Edyn	[m]	asphalt Edyn	[m]	strain [µm]	Asphalt F78	deformation sub	Neq/fatigue
1	750	7,58E+06	65	0,3	150	0,25	600	0,25	7500	0,17	71	8,98E+06		0,84
											-186		1,63E+08	0,05
2	500	5,05E+06	65	0,3	150	0,25	600	0,25	7500	0,15	78	5,22E+06		0,97
											-202		1,16E+08	0,04
3	250	2,53E+06	65	0,3	150	0,25	600	0,25	7500	0,13	88	2,78E+06		0,91
											-220		8,29E+07	0,03
4	100	1,01E+06	65	0,3	150	0,25	600	0,25	7500	0,1	106	1,09E+06		0,92
											-250		5,01E+07	0,02
5	50	5,05E+05	65	0,3	150	0,25	600	0,25	7500	0,08	117	6,28E+05		0,80
											-271		3,60E+07	0,01

Calculations traditional constructions:

Soiltype 2 Edyn: 50 Mpa

Project number: Unesco - Floods Tabasco
Date: 5-12-2011
By: Pascal Lakerveld

= invullen

Assumptions			
Design lifespan	10	years	
Type of vehicle	Vrachtwagen		
Axle configuration	dubbel lucht		
Tire pressure	0,577	MPa	
Standard axle load	80	KN	
Amount of working days	270	days	
Vehicle damage factor	1,9		
Growth per year	2%		
Lane correction factor	1	1;0,95;0,9	
Width tire factor	40	1,8	(bij asfalt < 150 mm)
speed of traffic	80		
reliability factor fatique relation sub	85%	1,037	

Traffic class	amount of traffic day	amount of traffic lifetime	Sand Edyn	Sand [m]	base coarse Edyn	base coarse [m]	topbase Edyn	topbase [m]	asphalt Edyn	asphalt [m]	strain [µm]	Asphalt F78	deformation sub	Neq/fatigue
1	750	7,58E+06	130	0,3	150	0,25	600	0,25	7500	0,16	72	8,30E+06		0,91
											-133		6,28E+08	0,01
2	500	5,05E+06	130	0,3	150	0,25	600	0,25	7500	0,15	76	6,19E+06		0,82
											-138		5,32E+08	0,01
3	250	2,53E+06	130	0,3	150	0,25	600	0,25	7500	0,13	86	3,18E+06		0,80
											-150		3,82E+08	0,01
4	100	1,01E+06	130	0,3	150	0,25	600	0,25	7500	0,1	104	1,17E+06		0,86
											-170		2,33E+08	0,00
5	50	5,05E+05	130	0,3	150	0,25	600	0,25	7500	0,08	117	6,36E+05		0,79
											-184		1,69E+08	0,00

Calculations traditional constructions:

Soiltype 3 Edyn: 75 Mpa

Project number: Unesco - Floods Tabasco
Date: 5-12-2011
By: Pascal Lakerveld

[ ] = invullen

Assumptions			
Design lifespan	10	years	
Type of vehicle	Vrachtwagen		
Axle configuration	dubbel lucht		
Tire pressure	0,577	MPa	
Standard axle load	80	KN	
Amount of working days	270	days	
Vehicle damage factor	1,9		
Growth per year	2%		
Lane correction factor	1	1;0,95;0,9	
Width tire factor	40	1,8	(bij asfalt < 150 mm)
speed of traffic	80		
reliability factor fatique relation sub	85%	1,037	

Traffic class	amount of traffic day	lifetime	Sand Edyn	[m]	base coarse Edyn	[m]	topbase Edyn	[m]	asphalt Edyn	[m]	strain [µm]	Asphalt F78	deformation sub	Neq/fatigue
1	750	7,58E+06	75		150	0,3	600	0,25	7500	0,16	72	8,19E+06		0,93
											-154		3,46E+08	0,02
2	500	5,05E+06	75		150	0,3	600	0,25	7500	0,15	76	6,09E+06		0,83
											-162		2,83E+08	0,02
3	250	2,53E+06	75		150	0,3	600	0,25	7500	0,13	87	3,11E+06		0,81
											-180		1,87E+08	0,01
4	100	1,01E+06	75		150	0,3	600	0,25	7500	0,1	105	1,14E+06		0,89
											-210		9,95E+07	0,01
5	50	5,05E+05	75		150	0,3	600	0,25	7500	0,08	118	6,17E+05		0,82
											-234		6,55E+07	0,01

Calculations traditional constructions:

Soiltype 4 Edyn: 100 Mpa

Project number: Unesco - Floods Tabasco
Date: 5-12-2011
By: Pascal Lakerveld

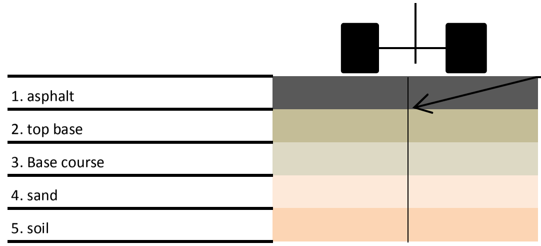
[yellow] = invullen

Assumptions		
Design lifespan	10	years
Type of vehicle	Vrachtwagen	
Axle configuration	dubbel lucht	
Tire pressure	0,577	MPa
Standard axle load	80	KN
Amount of working days	270	days
Vehicle damage factor	1,9	
Growth per year	2%	
Lane correction factor	1	1;0,95;0,9
Width tire factor	40	1,8 (bij asfalt < 150 mm)
speed of traffic	80	
reliability factor fatique relation sub	85%	1,037

Traffic	amount of traffic		Sand		base coarse		topbase		asphalt		strain	Asphalt	deformation	Neq/fatigue
class	day	lifetime	Edyn	[m]	Edyn	[m]	Edyn	[m]	Edyn	[m]	[µm]	F78	sub	
1	750	7,58E+06	100		150	0,3	600	0,25	7500	0,16	71	8,68E+06		0,87
											-130		6,77E+08	0,01
2	500	5,05E+06	100		150	0,3	600	0,25	7500	0,15	75	6,42E+06		0,79
											-137		5,52E+08	0,01
3	250	2,53E+06	100		150	0,3	600	0,25	7500	0,13	86	3,23E+06		0,78
											-152		3,66E+08	0,01
4	100	1,01E+06	100		150	0,3	600	0,25	7500	0,1	105	1,16E+06		0,87
											-178		1,95E+08	0,01
5	50	5,05E+05	100		150	0,3	600	0,25	7500	0,08	118	6,17E+05		0,82
											-197		1,29E+08	0,00

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Calculation position: 1

Soil type 1 **Traffic class 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,17	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	6,50E+01	0,35
5		2,50E+01	0,35

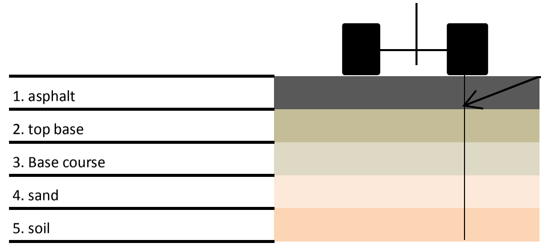
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,70E-01	6,47E-01	4,04E-01	-7,04E-02	7,07E+01	2,69E+01	-5,84E+01	0,00E+00	0,00E+00	4,56E+02
2	1	0,00E+00	-1,58E-01	1,70E-01	6,97E-01	5,77E-01	-7,99E-02	6,97E+01	4,81E+01	-7,01E+01	0,00E+00	-6,00E+00	4,51E+02
3	2	0,00E+00	0,00E+00	4,20E-01	6,94E-02	6,40E-02	-1,84E-02	8,92E+01	7,69E+01	-1,09E+02	0,00E+00	0,00E+00	4,30E+02
4	2	0,00E+00	-1,58E-01	4,20E-01	6,58E-02	5,90E-02	-1,71E-02	8,53E+01	6,99E+01	-1,01E+02	0,00E+00	-1,18E+01	4,24E+02
5	3	0,00E+00	0,00E+00	6,70E-01	1,47E-02	1,41E-02	-7,77E-03	8,30E+01	7,81E+01	-1,19E+02	0,00E+00	0,00E+00	3,96E+02
6	3	0,00E+00	-1,58E-01	6,70E-01	1,42E-02	1,33E-02	-7,44E-03	8,10E+01	7,31E+01	-1,14E+02	0,00E+00	-1,20E+01	3,93E+02
7	4	0,00E+00	0,00E+00	9,70E-01	5,25E-03	5,13E-03	-4,23E-03	7,59E+01	7,35E+01	-1,21E+02	0,00E+00	0,00E+00	3,56E+02
8	4	0,00E+00	-1,58E-01	9,70E-01	5,14E-03	4,93E-03	-4,15E-03	7,48E+01	7,05E+01	-1,18E+02	0,00E+00	-1,14E+01	3,54E+02
9	5	0,00E+00	0,00E+00	9,70E-01	6,15E-04	5,71E-04	-4,23E-03	7,59E+01	7,35E+01	-1,86E+02	0,00E+00	0,00E+00	3,56E+02
10	5	0,00E+00	-1,58E-01	9,70E-01	6,01E-04	5,22E-04	-4,15E-03	7,48E+01	7,05E+01	-1,82E+02	0,00E+00	-1,14E+01	3,54E+02

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Calculation position: 2

Soil type 1 **Traffic class 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,15	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	6,50E+01	0,35
5		2,50E+01	0,35

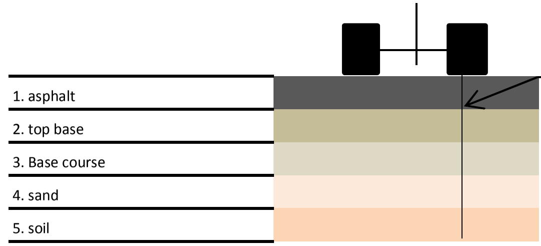
Load Number	Load Vertical (kN)	Stress Vertical (MPa)	Load Horz. (Shear) (kN)	Stress Horz. (Shear) (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Angle Shear (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,50E-01	6,93E-01	3,86E-01	-8,23E-02	7,83E+01	2,29E+01	-6,13E+01	0,00E+00	0,00E+00	4,81E+02
2	1	0,00E+00	-1,58E-01	1,50E-01	7,78E-01	6,40E-01	-9,73E-02	7,84E+01	5,36E+01	-7,92E+01	0,00E+00	-6,14E+00	4,75E+02
3	2	0,00E+00	0,00E+00	4,00E-01	7,81E-02	7,12E-02	-2,14E-02	1,01E+02	8,56E+01	-1,23E+02	0,00E+00	0,00E+00	4,51E+02
4	2	0,00E+00	-1,58E-01	4,00E-01	7,37E-02	6,53E-02	-1,98E-02	9,63E+01	7,74E+01	-1,14E+02	0,00E+00	-1,31E+01	4,45E+02
5	3	0,00E+00	0,00E+00	6,50E-01	1,62E-02	1,56E-02	-8,70E-03	9,21E+01	8,62E+01	-1,32E+02	0,00E+00	0,00E+00	4,14E+02
6	3	0,00E+00	-1,58E-01	6,50E-01	1,57E-02	1,46E-02	-8,29E-03	8,97E+01	8,02E+01	-1,26E+02	0,00E+00	-1,33E+01	4,10E+02
7	4	0,00E+00	0,00E+00	9,50E-01	5,75E-03	5,61E-03	-4,59E-03	8,29E+01	8,01E+01	-1,32E+02	0,00E+00	0,00E+00	3,70E+02
8	4	0,00E+00	-1,58E-01	9,50E-01	5,62E-03	5,38E-03	-4,49E-03	8,16E+01	7,66E+01	-1,28E+02	0,00E+00	-1,24E+01	3,67E+02
9	5	0,00E+00	0,00E+00	9,50E-01	6,88E-04	6,36E-04	-4,59E-03	8,29E+01	8,01E+01	-2,02E+02	0,00E+00	0,00E+00	3,70E+02
10	5	0,00E+00	-1,58E-01	9,50E-01	6,72E-04	5,79E-04	-4,49E-03	8,16E+01	7,66E+01	-1,97E+02	0,00E+00	-1,24E+01	3,67E+0[illegible]

= normative value for further calculations (fatique relation)

Project: Unesco - Floods Tabasco

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Calculation position: 2

Soil type 1 **Traffic class 3**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,13	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	6,50E+01	0,35
5		2,50E+01	0,35

Load Number	Load Vertical (kN)	Stress Vertical (MPa)	Load Horz. (Shear) (kN)	Stress Horz. (Shear) (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Angle Shear (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,30E-01	7,35E-01	3,41E-01	-9,67E-02	8,66E+01	1,57E+01	-6,31E+01	0,00E+00	0,00E+00	5,08E+02
2	1	0,00E+00	-1,58E-01	1,30E-01	8,71E-01	7,13E-01	-1,20E-01	8,84E+01	6,01E+01	-9,00E+01	0,00E+00	-6,13E+00	5,01E+02
3	2	0,00E+00	0,00E+00	3,80E-01	8,82E-02	7,94E-02	-2,50E-02	1,15E+02	9,54E+01	-1,39E+02	0,00E+00	0,00E+00	4,74E+02
4	2	0,00E+00	-1,58E-01	3,80E-01	8,30E-02	7,25E-02	-2,30E-02	1,09E+02	8,59E+01	-1,29E+02	0,00E+00	-1,46E+01	4,67E+02
5	3	0,00E+00	0,00E+00	6,30E-01	1,80E-02	1,71E-02	-9,78E-03	1,03E+02	9,52E+01	-1,47E+02	0,00E+00	0,00E+00	4,32E+02
6	3	0,00E+00	-1,58E-01	6,30E-01	1,73E-02	1,60E-02	-9,28E-03	9,96E+01	8,80E+01	-1,40E+02	0,00E+00	-1,46E+01	4,27E+02
7	4	0,00E+00	0,00E+00	9,30E-01	6,29E-03	6,13E-03	-4,99E-03	9,06E+01	8,73E+01	-1,44E+02	0,00E+00	0,00E+00	3,84E+02
8	4	0,00E+00	-1,58E-01	9,30E-01	6,14E-03	5,85E-03	-4,87E-03	8,91E+01	8,32E+01	-1,39E+02	0,00E+00	-1,35E+01	3,81E+02
9	5	0,00E+00	0,00E+00	9,30E-01	7,67E-04	7,05E-04	-4,99E-03	9,06E+01	8,73E+01	-2,20E+02	0,00E+00	0,00E+00	3,84E+02
10	5	0,00E+00	-1,58E-01	9,30E-01	7,48E-04	6,38E-04	-4,87E-03	8,91E+01	8,32E+01	-2,14E+02	0,00E+00	-1,35E+01	3,81E[illegible]

= normative value for further calculations (fatique relation)

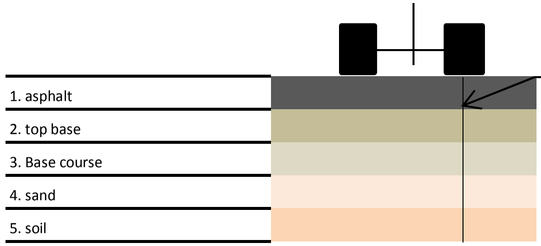
Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 1 **Traffic class 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,1	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	6,50E+01	0,35
5		2,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

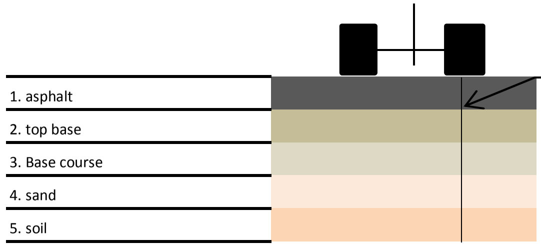
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,00E-01	7,62E-01	1,78E-01	-1,23E-01	9,91E+01	-6,07E+00	-6,03E+01	0,00E+00	0,00E+00	5,53E+02
2	1	0,00E+00	-1,58E-01	1,00E-01	1,03E+00	8,39E-01	-1,71E-01	1,06E+02	7,20E+01	-1,10E+02	0,00E+00	-5,54E+00	5,47E+02
3	2	0,00E+00	0,00E+00	3,50E-01	1,07E-01	9,36E-02	-3,20E-02	1,43E+02	1,12E+02	-1,70E+02	0,00E+00	0,00E+00	5,12E+02
4	2	0,00E+00	-1,58E-01	3,50E-01	1,00E-01	8,52E-02	-2,93E-02	1,34E+02	1,01E+02	-1,57E+02	0,00E+00	-1,71E+01	5,03E+02
5	3	0,00E+00	0,00E+00	6,00E-01	2,10E-02	1,98E-02	-1,17E-02	1,21E+02	1,10E+02	-1,73E+02	0,00E+00	0,00E+00	4,61E+02
6	3	0,00E+00	-1,58E-01	6,00E-01	2,01E-02	1,83E-02	-1,10E-02	1,17E+02	1,01E+02	-1,63E+02	0,00E+00	-1,69E+01	4,56E+02
7	4	0,00E+00	0,00E+00	9,00E-01	7,19E-03	6,98E-03	-5,64E-03	1,03E+02	9,90E+01	-1,63E+02	0,00E+00	0,00E+00	4,06E+02
8	4	0,00E+00	-1,58E-01	9,00E-01	6,99E-03	6,62E-03	-5,49E-03	1,02E+02	9,38E+01	-1,58E+02	0,00E+00	-1,53E+01	4,02E+02
9	5	0,00E+00	0,00E+00	9,00E-01	8,95E-04	8,13E-04	-5,64E-03	1,03E+02	9,90E+01	-2,50E+02	0,00E+00	0,00E+00	4,06E+02
10	5	0,00E+00	-1,58E-01	9,00E-01	8,70E-04	7,28E-04	-5,49E-03	1,02E+02	9,38E+01	-2,42E+02	0,00E+00	-1,53E+01	4,02[illegible]

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 1 **Traffic class 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,08	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	6,50E+01	0,35
5		2,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

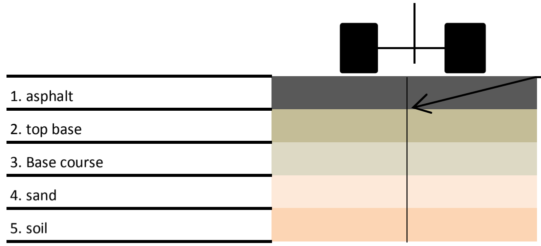
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	8,00E-02	7,19E-01	-5,27E-02	-1,42E-01	1,05E+02	-3,40E+01	-5,00E+01	0,00E+00	0,00E+00	5,86E+02
2	1	0,00E+00	-1,58E-01	8,00E-02	1,13E+00	9,32E-01	-2,24E-01	1,17E+02	8,20E+01	-1,26E+02	0,00E+00	-4,42E+00	5,82E+02
3	2	0,00E+00	0,00E+00	3,30E-01	1,23E-01	1,04E-01	-3,78E-02	1,66E+02	1,24E+02	-1,95E+02	0,00E+00	0,00E+00	5,40E+02
4	2	0,00E+00	-1,58E-01	3,30E-01	1,14E-01	9,50E-02	-3,47E-02	1,55E+02	1,12E+02	-1,80E+02	0,00E+00	-1,90E+01	5,29E+02
5	3	0,00E+00	0,00E+00	5,80E-01	2,32E-02	2,17E-02	-1,32E-02	1,35E+02	1,21E+02	-1,93E+02	0,00E+00	0,00E+00	4,82E+02
6	3	0,00E+00	-1,58E-01	5,80E-01	2,21E-02	1,99E-02	-1,24E-02	1,30E+02	1,10E+02	-1,81E+02	0,00E+00	-1,85E+01	4,76E+02
7	4	0,00E+00	0,00E+00	8,80E-01	7,83E-03	7,57E-03	-6,13E-03	1,13E+02	1,07E+02	-1,77E+02	0,00E+00	0,00E+00	4,21E+02
8	4	0,00E+00	-1,58E-01	8,80E-01	7,60E-03	7,16E-03	-5,95E-03	1,10E+02	1,01E+02	-1,71E+02	0,00E+00	-1,66E+01	4,17E+02
9	5	0,00E+00	0,00E+00	8,80E-01	9,80E-04	8,82E-04	-6,13E-03	1,13E+02	1,07E+02	-2,71E+02	0,00E+00	0,00E+00	4,21E+02
10	5	0,00E+00	-1,58E-01	8,80E-01	9,51E-04	7,82E-04	-5,95E-03	1,10E+02	1,01E+02	-2,62E+02	0,00E+00	-1,66E+01	4,17E[illegible]

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed

Calculation position: 1



Soil type 2 **Traffic class 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,16	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	1,30E+02	0,35
5		5,00E+01	0,35

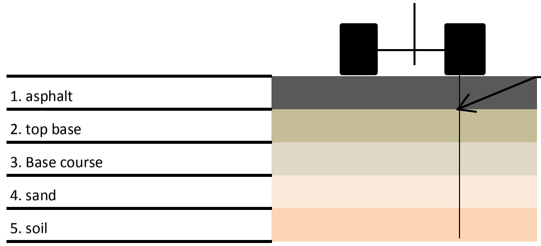
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,60E-01	6,39E-01	3,66E-01	-7,80E-02	7,18E+01	2,27E+01	-5,73E+01	0,00E+00	0,00E+00	3,03E+02
2	1	0,00E+00	-1,58E-01	1,60E-01	7,05E-01	5,77E-01	-8,99E-02	7,13E+01	4,83E+01	-7,18E+01	0,00E+00	-5,68E+00	2,98E+02
3	2	0,00E+00	0,00E+00	4,10E-01	6,08E-02	5,47E-02	-2,38E-02	8,32E+01	6,96E+01	-1,07E+02	0,00E+00	0,00E+00	2,76E+02
4	2	0,00E+00	-1,58E-01	4,10E-01	5,70E-02	4,96E-02	-2,21E-02	7,90E+01	6,22E+01	-9,89E+01	0,00E+00	-1,06E+01	2,71E+02
5	3	0,00E+00	0,00E+00	6,60E-01	6,22E-03	5,80E-03	-1,17E-02	5,53E+01	5,15E+01	-1,06E+02	0,00E+00	0,00E+00	2,42E+02
6	3	0,00E+00	-1,58E-01	6,60E-01	6,06E-03	5,38E-03	-1,12E-02	5,39E+01	4,77E+01	-1,01E+02	0,00E+00	-7,91E+00	2,39E+02
7	4	0,00E+00	0,00E+00	9,60E-01	7,27E-03	7,08E-03	-6,12E-03	5,34E+01	5,13E+01	-8,57E+01	0,00E+00	0,00E+00	2,14E+02
8	4	0,00E+00	-1,58E-01	9,60E-01	7,09E-03	6,74E-03	-5,97E-03	5,24E+01	4,89E+01	-8,32E+01	0,00E+00	-7,96E+00	2,12E+02
9	5	0,00E+00	0,00E+00	9,60E-01	7,66E-04	6,92E-04	-6,12E-03	5,34E+01	5,13E+01	-1,33E+02	0,00E+00	0,00E+00	2,14E+02
10	5	0,00E+00	-1,58E-01	9,60E-01	7,48E-04	6,16E-04	-5,97E-03	5,24E+01	4,89E+01	-1,29E+02	0,00E+00	-7,96E+00	2,12E+[illegible]

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Calculation position: 3

Soil type 2 **Traffic class 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,15	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	1,30E+02	0,35
5		5,00E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,50E-01	6,63E-01	3,56E-01	-8,43E-02	7,57E+01	2,05E+01	-5,88E+01	0,00E+00	0,00E+00	3,13E+02
2	1	0,00E+00	-1,58E-01	1,50E-01	7,49E-01	6,11E-01	-9,91E-02	7,59E+01	5,12E+01	-7,67E+01	0,00E+00	-5,75E+00	3,07E+02
3	2	0,00E+00	0,00E+00	4,00E-01	6,47E-02	5,79E-02	-2,55E-02	8,89E+01	7,36E+01	-1,14E+02	0,00E+00	0,00E+00	2,84E+02
4	2	0,00E+00	-1,58E-01	4,00E-01	6,06E-02	5,23E-02	-2,36E-02	8,42E+01	6,56E+01	-1,05E+02	0,00E+00	-1,12E+01	2,78E+02
5	3	0,00E+00	0,00E+00	6,50E-01	6,49E-03	6,03E-03	-1,24E-02	5,81E+01	5,40E+01	-1,12E+02	0,00E+00	0,00E+00	2,47E+02
6	3	0,00E+00	-1,58E-01	6,50E-01	6,31E-03	5,56E-03	-1,18E-02	5,66E+01	4,98E+01	-1,06E+02	0,00E+00	-8,28E+00	2,44E+02
7	4	0,00E+00	0,00E+00	9,50E-01	7,59E-03	7,38E-03	-6,38E-03	5,57E+01	5,35E+01	-8,94E+01	0,00E+00	0,00E+00	2,18E+02
8	4	0,00E+00	-1,58E-01	9,50E-01	7,40E-03	7,03E-03	-6,21E-03	5,47E+01	5,08E+01	-8,66E+01	0,00E+00	-8,29E+00	2,16E+02
9	5	0,00E+00	0,00E+00	9,50E-01	8,08E-04	7,27E-04	-6,38E-03	5,57E+01	5,35E+01	-1,38E+02	0,00E+00	0,00E+00	2,18E+02
10	5	0,00E+00	-1,58E-01	9,50E-01	7,89E-04	6,45E-04	-6,21E-03	5,47E+01	5,08E+01	-1,34E+02	0,00E+00	-8,29E+00	2,16E[illegible]

(yellow) = normative value for further calculations (fatique relation)

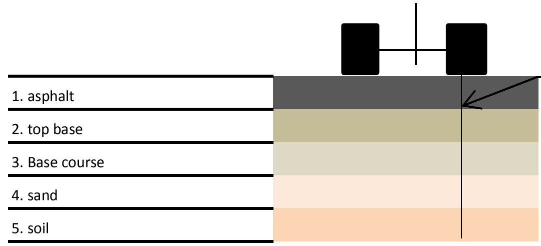
Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 2 **Traffic class 3**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,13	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	1,30E+02	0,35
5		5,00E+01	0,35

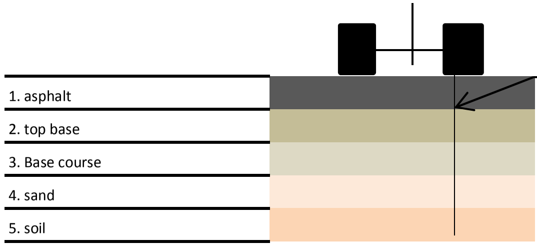
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,30E-01	7,08E-01	3,15E-01	-9,86E-02	8,43E+01	1,35E+01	-6,09E+01	0,00E+00	0,00E+00	3,32E+02
2	1	0,00E+00	-1,58E-01	1,30E-01	8,44E-01	6,88E-01	-1,22E-01	8,62E+01	5,80E+01	-8,78E+01	0,00E+00	-5,79E+00	3,26E+02
3	2	0,00E+00	0,00E+00	3,80E-01	7,37E-02	6,49E-02	-2,95E-02	1,02E+02	8,24E+01	-1,30E+02	0,00E+00	0,00E+00	2,99E+02
4	2	0,00E+00	-1,58E-01	3,80E-01	6,87E-02	5,84E-02	-2,72E-02	9,63E+01	7,31E+01	-1,20E+02	0,00E+00	-1,25E+01	2,93E+02
5	3	0,00E+00	0,00E+00	6,30E-01	7,07E-03	6,50E-03	-1,39E-02	6,45E+01	5,93E+01	-1,25E+02	0,00E+00	0,00E+00	2,58E+02
6	3	0,00E+00	-1,58E-01	6,30E-01	6,84E-03	5,95E-03	-1,32E-02	6,24E+01	5,44E+01	-1,18E+02	0,00E+00	-9,08E+00	2,55E+02
7	4	0,00E+00	0,00E+00	9,30E-01	8,29E-03	8,04E-03	-6,92E-03	6,07E+01	5,81E+01	-9,72E+01	0,00E+00	0,00E+00	2,26E+02
8	4	0,00E+00	-1,58E-01	9,30E-01	8,06E-03	7,62E-03	-6,72E-03	5,96E+01	5,50E+01	-9,39E+01	0,00E+00	-8,99E+00	2,24E+02
9	5	0,00E+00	0,00E+00	9,30E-01	8,96E-04	8,00E-04	-6,92E-03	6,07E+01	5,81E+01	-1,50E+02	0,00E+00	0,00E+00	2,26E+02
10	5	0,00E+00	-1,58E-01	9,30E-01	8,74E-04	7,04E-04	-6,72E-03	5,96E+01	5,50E+01	-1,45E+02	0,00E+00	-8,99E+00	2,24[illegible]

(yellow) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Calculation position: 2

Soil type 2 **Traffic class 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,1	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	1,30E+02	0,35
5		5,00E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

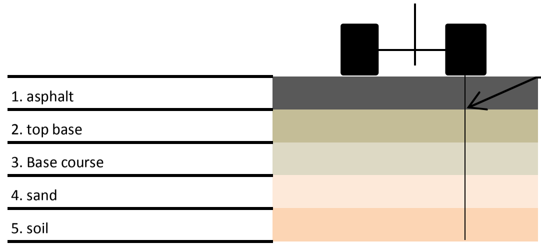
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,00E-01	7,45E-01	1,62E-01	-1,25E-01	9,77E+01	-7,40E+00	-5,90E+01	0,00E+00	0,00E+00	3,66E+02
2	1	0,00E+00	-1,58E-01	1,00E-01	1,01E+00	8,23E-01	-1,73E-01	1,04E+02	7,07E+01	-1,09E+02	0,00E+00	-5,33E+00	3,60E+02
3	2	0,00E+00	0,00E+00	3,50E-01	9,08E-02	7,73E-02	-3,72E-02	1,28E+02	9,75E+01	-1,60E+02	0,00E+00	0,00E+00	3,26E+02
4	2	0,00E+00	-1,58E-01	3,50E-01	8,41E-02	6,94E-02	-3,41E-02	1,20E+02	8,64E+01	-1,46E+02	0,00E+00	-1,48E+01	3,18E+02
5	3	0,00E+00	0,00E+00	6,00E-01	8,05E-03	7,25E-03	-1,66E-02	7,56E+01	6,83E+01	-1,47E+02	0,00E+00	0,00E+00	2,76E+02
6	3	0,00E+00	-1,58E-01	6,00E-01	7,75E-03	6,53E-03	-1,56E-02	7,28E+01	6,18E+01	-1,37E+02	0,00E+00	-1,04E+01	2,72E+02
7	4	0,00E+00	0,00E+00	9,00E-01	9,44E-03	9,11E-03	-7,82E-03	6,91E+01	6,57E+01	-1,10E+02	0,00E+00	0,00E+00	2,39E+02
8	4	0,00E+00	-1,58E-01	9,00E-01	9,14E-03	8,57E-03	-7,56E-03	6,76E+01	6,17E+01	-1,06E+02	0,00E+00	-1,01E+01	2,36E+02
9	5	0,00E+00	0,00E+00	9,00E-01	1,04E-03	9,13E-04	-7,82E-03	6,91E+01	6,57E+01	-1,70E+02	0,00E+00	0,00E+00	2,39E+02
10	5	0,00E+00	-1,58E-01	9,00E-01	1,01E-03	7,92E-04	-7,56E-03	6,76E+01	6,17E+01	-1,64E+02	0,00E+00	-1,01E+01	2,36E[illegible]

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 2 **Traffic class 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,08	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,25	1,50E+02	0,35
4	0,3	1,30E+02	0,35
5		5,00E+01	0,35

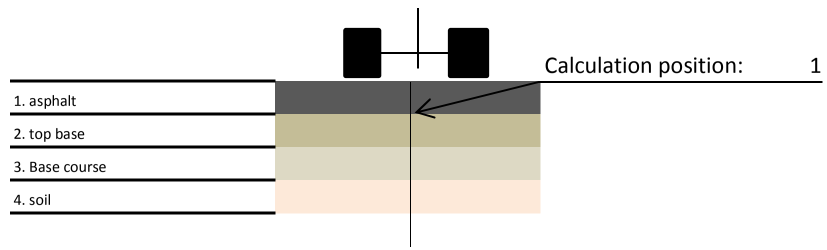
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	8,00E-02	7,14E-01	-5,71E-02	-1,43E-01	1,05E+02	-3,43E+01	-4,97E+01	0,00E+00	0,00E+00	3,91E+02
2	1	0,00E+00	-1,58E-01	8,00E-02	1,12E+00	9,28E-01	-2,25E-01	1,17E+02	8,18E+01	-1,26E+02	0,00E+00	-4,37E+00	3,87E+02
3	2	0,00E+00	0,00E+00	3,30E-01	1,05E-01	8,63E-02	-4,35E-02	1,50E+02	1,08E+02	-1,84E+02	0,00E+00	0,00E+00	3,45E+02
4	2	0,00E+00	-1,58E-01	3,30E-01	9,71E-02	7,81E-02	-3,99E-02	1,40E+02	9,68E+01	-1,69E+02	0,00E+00	-1,65E+01	3,36E+02
5	3	0,00E+00	0,00E+00	5,80E-01	8,76E-03	7,73E-03	-1,88E-02	8,41E+01	7,48E+01	-1,64E+02	0,00E+00	0,00E+00	2,89E+02
6	3	0,00E+00	-1,58E-01	5,80E-01	8,40E-03	6,90E-03	-1,75E-02	8,06E+01	6,71E+01	-1,52E+02	0,00E+00	-1,14E+01	2,84E+02
7	4	0,00E+00	0,00E+00	8,80E-01	1,03E-02	9,86E-03	-8,47E-03	7,51E+01	7,10E+01	-1,19E+02	0,00E+00	0,00E+00	2,48E+02
8	4	0,00E+00	-1,58E-01	8,80E-01	9,90E-03	9,23E-03	-8,18E-03	7,33E+01	6,64E+01	-1,14E+02	0,00E+00	-1,09E+01	2,45E+02
9	5	0,00E+00	0,00E+00	8,80E-01	1,13E-03	9,82E-04	-8,47E-03	7,51E+01	7,10E+01	-1,84E+02	0,00E+00	0,00E+00	2,48E+02
10	5	0,00E+00	-1,58E-01	8,80E-01	1,10E-03	8,43E-04	-8,18E-03	7,34E+01	6,64E+01	-1,77E+02	0,00E+00	-1,09E+01	2,4[illegible]

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Soil type 3 **Traffic class 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,16	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

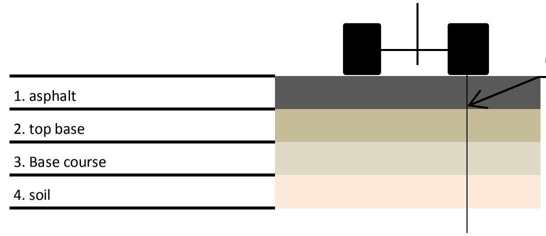
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,60E-01	6,41E-01	3,69E-01	-7,78E-02	7,19E+01	2,29E+01	-5,75E+01	0,00E+00	0,00E+00	2,60E+02
2	1	0,00E+00	-1,58E-01	1,60E-01	7,07E-01	5,79E-01	-8,96E-02	7,15E+01	4,84E+01	-7,20E+01	0,00E+00	-5,71E+00	2,54E+02
3	2	0,00E+00	0,00E+00	4,10E-01	6,07E-02	5,46E-02	-2,35E-02	8,29E+01	6,93E+01	-1,06E+02	0,00E+00	0,00E+00	2,33E+02
4	2	0,00E+00	-1,58E-01	4,10E-01	5,69E-02	4,94E-02	-2,19E-02	7,87E+01	6,19E+01	-9,84E+01	0,00E+00	-1,05E+01	2,28E+02
5	3	0,00E+00	0,00E+00	7,10E-01	8,18E-03	7,73E-03	-1,08E-02	6,17E+01	5,76E+01	-1,09E+02	0,00E+00	0,00E+00	1,93E+02
6	3	0,00E+00	-1,58E-01	7,10E-01	7,86E-03	7,12E-03	-1,04E-02	6,00E+01	5,33E+01	-1,04E+02	0,00E+00	-8,85E+00	1,90E+02
7	4	0,00E+00	0,00E+00	7,10E-01	1,18E-03	9,57E-04	-1,08E-02	6,17E+01	5,76E+01	-1,54E+02	0,00E+00	0,00E+00	1,93E+02
8	4	0,00E+00	-1,58E-01	7,10E-01	1,14E-03	7,65E-04	-1,04E-02	6,00E+01	5,33E+01	-1,47E+02	0,00E+00	-8,85E+00	1,90E+02

(highlighted) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 3 **Traffic class 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,15	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		7,50E+01	0,35

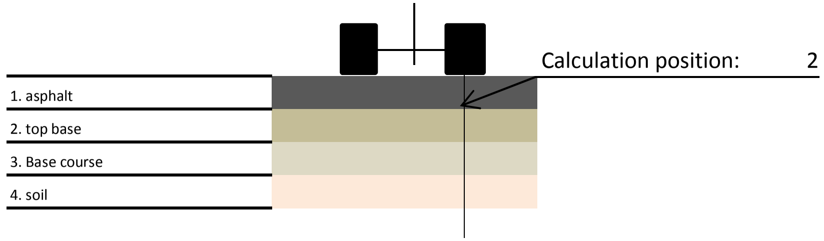
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,50E-01	6,66E-01	3,59E-01	-8,40E-02	7,60E+01	2,07E+01	-5,90E+01	0,00E+00	0,00E+00	2,68E+02
2	1	0,00E+00	-1,58E-01	1,50E-01	7,51E-01	6,14E-01	-9,89E-02	7,61E+01	5,14E+01	-7,69E+01	0,00E+00	-5,79E+00	2,63E+02
3	2	0,00E+00	0,00E+00	4,00E-01	6,47E-02	5,79E-02	-2,52E-02	8,87E+01	7,34E+01	-1,13E+02	0,00E+00	0,00E+00	2,40E+02
4	2	0,00E+00	-1,58E-01	4,00E-01	6,05E-02	5,22E-02	-2,34E-02	8,40E+01	6,54E+01	-1,05E+02	0,00E+00	-1,12E+01	2,34E+02
5	3	0,00E+00	0,00E+00	7,00E-01	8,64E-03	8,14E-03	-1,14E-02	6,51E+01	6,06E+01	-1,15E+02	0,00E+00	0,00E+00	1,97E+02
6	3	0,00E+00	-1,58E-01	7,00E-01	8,29E-03	7,48E-03	-1,09E-02	6,32E+01	5,59E+01	-1,09E+02	0,00E+00	-9,30E+00	1,94E+02
7	4	0,00E+00	0,00E+00	7,00E-01	1,26E-03	1,02E-03	-1,14E-02	6,51E+01	6,06E+01	-1,62E+02	0,00E+00	0,00E+00	1,97E+02
8	4	0,00E+00	-1,58E-01	7,00E-01	1,21E-03	8,07E-04	-1,09E-02	6,32E+01	5,59E+01	-1,55E+02	0,00E+00	-9,30E+00	1,94E+02

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed



Soil type 3 **Traffic class 3**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,13	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		7,50E+01	0,35

Load Number	Load Vertical (kN)	Stress Vertical (MPa)	Load Horz. (Shear) (kN)	Stress Horz. (Shear) (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Angle Shear (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

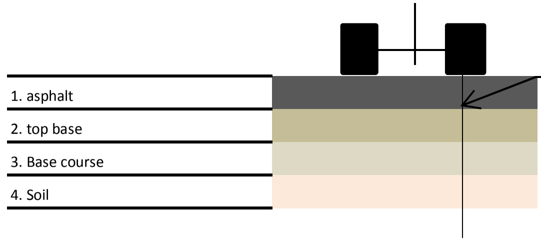
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,30E-01	7,12E-01	3,19E-01	-9,83E-02	8,47E+01	1,39E+01	-6,12E+01	0,00E+00	0,00E+00	2,87E+02
2	1	0,00E+00	-1,58E-01	1,30E-01	8,49E-01	6,92E-01	-1,22E-01	8,66E+01	5,83E+01	-8,81E+01	0,00E+00	-5,85E+00	2,82E+02
3	2	0,00E+00	0,00E+00	3,80E-01	7,39E-02	6,51E-02	-2,91E-02	1,02E+02	8,23E+01	-1,30E+02	0,00E+00	0,00E+00	2,54E+02
4	2	0,00E+00	-1,58E-01	3,80E-01	6,88E-02	5,85E-02	-2,69E-02	9,63E+01	7,30E+01	-1,19E+02	0,00E+00	-1,25E+01	2,48E+02
5	3	0,00E+00	0,00E+00	6,80E-01	9,67E-03	9,05E-03	-1,26E-02	7,27E+01	6,71E+01	-1,28E+02	0,00E+00	0,00E+00	2,07E+02
6	3	0,00E+00	-1,58E-01	6,80E-01	9,24E-03	8,25E-03	-1,20E-02	7,04E+01	6,15E+01	-1,21E+02	0,00E+00	-1,03E+01	2,03E+02
7	4	0,00E+00	0,00E+00	6,80E-01	1,45E-03	1,14E-03	-1,26E-02	7,27E+01	6,71E+01	-1,80E+02	0,00E+00	0,00E+00	2,07E+02
8	4	0,00E+00	-1,58E-01	6,80E-01	1,39E-03	8,93E-04	-1,20E-02	7,04E+01	6,15E+01	-1,71E+02	0,00E+00	-1,03E+01	2,03E+02

[yellow] = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011
Calculated by: ing. Pascal Lakerveld
Controlled by: ir. Ing. Christophe Egyed

Calculation position: 2



Soil type 3 **Traffic class 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,1	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,00E-01	7,52E-01	1,69E-01	-1,24E-01	9,83E+01	-6,83E+00	-5,96E+01	0,00E+00	0,00E+00	3,20E+02
2	1	0,00E+00	-1,58E-01	1,00E-01	1,02E+00	8,30E-01	-1,72E-01	1,05E+02	7,13E+01	-1,09E+02	0,00E+00	-5,42E+00	3,14E+02
3	2	0,00E+00	0,00E+00	3,50E-01	9,14E-02	7,79E-02	-3,65E-02	1,28E+02	9,78E+01	-1,60E+02	0,00E+00	0,00E+00	2,80E+02
4	2	0,00E+00	-1,58E-01	3,50E-01	8,47E-02	6,99E-02	-3,36E-02	1,20E+02	8,67E+01	-1,46E+02	0,00E+00	-1,49E+01	2,71E+02
5	3	0,00E+00	0,00E+00	6,50E-01	1,15E-02	1,06E-02	-1,47E-02	8,59E+01	7,82E+01	-1,49E+02	0,00E+00	0,00E+00	2,22E+02
6	3	0,00E+00	-1,58E-01	6,50E-01	1,09E-02	9,54E-03	-1,39E-02	8,28E+01	7,08E+01	-1,41E+02	0,00E+00	-1,19E+01	2,18E+02
7	4	0,00E+00	0,00E+00	6,50E-01	1,77E-03	1,34E-03	-1,47E-02	8,59E+01	7,82E+01	-2,10E+02	0,00E+00	0,00E+00	2,22E+02
8	4	0,00E+00	-1,58E-01	6,50E-01	1,69E-03	1,02E-03	-1,39E-02	8,28E+01	7,08E+01	-1,99E+02	0,00E+00	-1,19E+01	2,18E+02

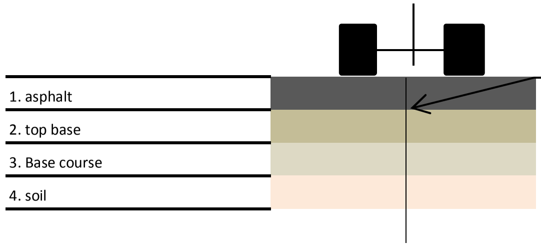
(yellow) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Soil type 3 **Traffic class 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,08	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	8,00E-02	7,23E-01	-4,85E-02	-1,43E-01	1,05E+02	-3,35E+01	-5,05E+01	0,00E+00	0,00E+00	3,44E+02
2	1	0,00E+00	-1,58E-01	8,00E-02	1,13E+00	9,37E-01	-2,25E-01	1,18E+02	8,25E+01	-1,27E+02	0,00E+00	-4,49E+00	3,40E+02
3	2	0,00E+00	0,00E+00	3,30E-01	1,06E-01	8,73E-02	-4,27E-02	1,51E+02	1,09E+02	-1,84E+02	0,00E+00	0,00E+00	2,98E+02
4	2	0,00E+00	-1,58E-01	3,30E-01	9,79E-02	7,89E-02	-3,93E-02	1,40E+02	9,73E+01	-1,69E+02	0,00E+00	-1,66E+01	2,89E+02
5	3	0,00E+00	0,00E+00	6,30E-01	1,28E-02	1,17E-02	-1,63E-02	9,60E+01	8,62E+01	-1,66E+02	0,00E+00	0,00E+00	2,33E+02
6	3	0,00E+00	-1,58E-01	6,30E-01	1,21E-02	1,05E-02	-1,54E-02	9,22E+01	7,74E+01	-1,55E+02	0,00E+00	-1,31E+01	2,29E+02
7	4	0,00E+00	0,00E+00	6,30E-01	2,01E-03	1,47E-03	-1,63E-02	9,60E+01	8,62E+01	-2,34E+02	0,00E+00	0,00E+00	2,33E+02
8	4	0,00E+00	-1,58E-01	6,30E-01	1,91E-03	1,09E-03	-1,54E-02	9,22E+01	7,74E+01	-2,19E+02	0,00E+00	-1,31E+01	2,29E+02

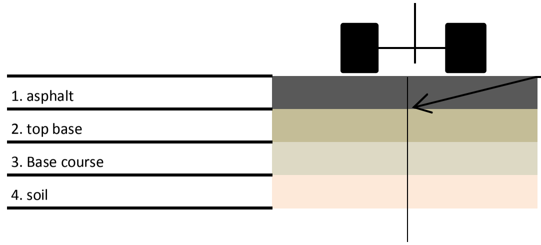
= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Calculation position: 1

Soil type 4 **Traffic class 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,16	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,60E-01	6,32E-01	3,59E-01	-7,85E-02	7,11E+01	2,21E+01	-5,67E+01	0,00E+00	0,00E+00	2,23E+02
2	1	0,00E+00	-1,58E-01	1,60E-01	6,98E-01	5,70E-01	-9,03E-02	7,07E+01	4,77E+01	-7,12E+01	0,00E+00	-5,59E+00	2,18E+02
3	2	0,00E+00	0,00E+00	4,10E-01	5,68E-02	5,08E-02	-2,50E-02	7,96E+01	6,61E+01	-1,04E+02	0,00E+00	0,00E+00	1,96E+02
4	2	0,00E+00	-1,58E-01	4,10E-01	5,30E-02	4,56E-02	-2,33E-02	7,54E+01	5,87E+01	-9,64E+01	0,00E+00	-1,00E+01	1,91E+02
5	3	0,00E+00	0,00E+00	7,10E-01	5,01E-03	4,62E-03	-1,23E-02	5,14E+01	4,79E+01	-1,05E+02	0,00E+00	0,00E+00	1,56E+02
6	3	0,00E+00	-1,58E-01	7,10E-01	4,80E-03	4,16E-03	-1,18E-02	4,99E+01	4,41E+01	-9,97E+01	0,00E+00	-7,34E+00	1,54E+02
7	4	0,00E+00	0,00E+00	7,10E-01	1,13E-03	8,65E-04	-1,23E-02	5,14E+01	4,79E+01	-1,30E+02	0,00E+00	0,00E+00	1,56E+02
8	4	0,00E+00	-1,58E-01	7,10E-01	1,08E-03	6,51E-04	-1,18E-02	4,99E+01	4,41E+01	-1,24E+02	0,00E+00	-7,34E+00	1,54E+02

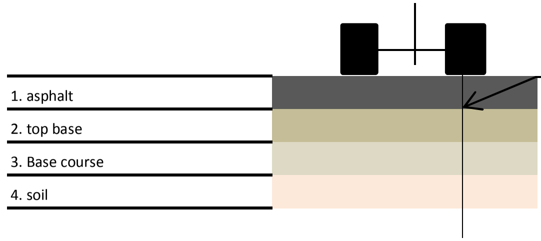
(yellow) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Calculation position: 2

Soil type 4 **Traffic class 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,15	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,50E-01	6,57E-01	3,50E-01	-8,47E-02	7,52E+01	1,99E+01	-5,83E+01	0,00E+00	0,00E+00	2,31E+02
2	1	0,00E+00	-1,58E-01	1,50E-01	7,42E-01	6,05E-01	-9,96E-02	7,54E+01	5,07E+01	-7,62E+01	0,00E+00	-5,67E+00	2,26E+02
3	2	0,00E+00	0,00E+00	4,00E-01	6,06E-02	5,38E-02	-2,68E-02	8,52E+01	7,00E+01	-1,11E+02	0,00E+00	0,00E+00	2,02E+02
4	2	0,00E+00	-1,58E-01	4,00E-01	5,65E-02	4,83E-02	-2,49E-02	8,06E+01	6,20E+01	-1,03E+02	0,00E+00	-1,06E+01	1,97E+02
5	3	0,00E+00	0,00E+00	7,00E-01	5,30E-03	4,87E-03	-1,30E-02	5,42E+01	5,03E+01	-1,10E+02	0,00E+00	0,00E+00	1,60E+02
6	3	0,00E+00	-1,58E-01	7,00E-01	5,08E-03	4,37E-03	-1,24E-02	5,26E+01	4,62E+01	-1,05E+02	0,00E+00	-7,71E+00	1,57E+02
7	4	0,00E+00	0,00E+00	7,00E-01	1,21E-03	9,19E-04	-1,30E-02	5,42E+01	5,03E+01	-1,37E+02	0,00E+00	0,00E+00	1,60E+02
8	4	0,00E+00	-1,58E-01	7,00E-01	1,16E-03	6,87E-04	-1,24E-02	5,26E+01	4,62E+01	-1,31E+02	0,00E+00	-7,71E+00	1,57E+02

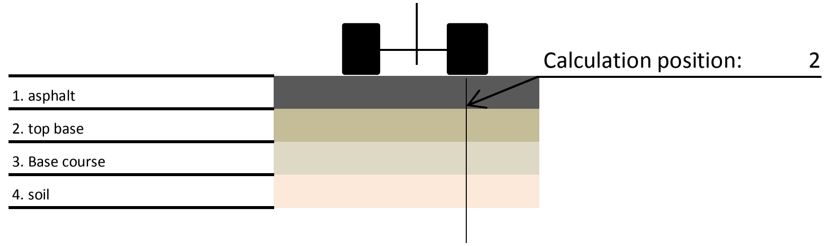
= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Soil type 4 **Traffic class 3**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,13	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,30E-01	7,04E-01	3,11E-01	-9,89E-02	8,40E+01	1,33E+01	-6,06E+01	0,00E+00	0,00E+00	2,48E+02
2	1	0,00E+00	-1,58E-01	1,30E-01	8,41E-01	6,84E-01	-1,22E-01	8,59E+01	5,77E+01	-8,75E+01	0,00E+00	-5,75E+00	2,43E+02
3	2	0,00E+00	0,00E+00	3,80E-01	6,95E-02	6,08E-02	-3,08E-02	9,84E+01	7,87E+01	-1,27E+02	0,00E+00	0,00E+00	2,16E+02
4	2	0,00E+00	-1,58E-01	3,80E-01	6,46E-02	5,43E-02	-2,85E-02	9,26E+01	6,94E+01	-1,17E+02	0,00E+00	-1,19E+01	2,09E+02
5	3	0,00E+00	0,00E+00	6,80E-01	5,95E-03	5,42E-03	-1,43E-02	6,05E+01	5,57E+01	-1,22E+02	0,00E+00	0,00E+00	1,68E+02
6	3	0,00E+00	-1,58E-01	6,80E-01	5,68E-03	4,82E-03	-1,37E-02	5,85E+01	5,08E+01	-1,16E+02	0,00E+00	-8,51E+00	1,65E+02
7	4	0,00E+00	0,00E+00	6,80E-01	1,39E-03	1,04E-03	-1,43E-02	6,05E+01	5,57E+01	-1,52E+02	0,00E+00	0,00E+00	1,68E+02
8	4	0,00E+00	-1,58E-01	6,80E-01	1,33E-03	7,60E-04	-1,37E-02	5,85E+01	5,08E+01	-1,44E+02	0,00E+00	-8,51E+00	1,65E+02

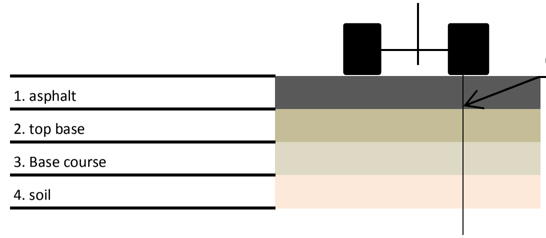
= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Soil type 4 **Traffic class 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,1	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	1,00E-01	7,48E-01	1,64E-01	-1,25E-01	9,79E+01	-7,17E+00	-5,92E+01	0,00E+00	0,00E+00	2,78E+02
2	1	0,00E+00	-1,58E-01	1,00E-01	1,01E+00	8,26E-01	-1,73E-01	1,05E+02	7,09E+01	-1,09E+02	0,00E+00	-5,37E+00	2,73E+02
3	2	0,00E+00	0,00E+00	3,50E-01	8,65E-02	7,31E-02	-3,84E-02	1,24E+02	9,37E+01	-1,57E+02	0,00E+00	0,00E+00	2,38E+02
4	2	0,00E+00	-1,58E-01	3,50E-01	7,99E-02	6,52E-02	-3,54E-02	1,16E+02	8,27E+01	-1,44E+02	0,00E+00	-1,42E+01	2,30E+02
5	3	0,00E+00	0,00E+00	6,50E-01	7,08E-03	6,34E-03	-1,68E-02	7,15E+01	6,48E+01	-1,43E+02	0,00E+00	0,00E+00	1,80E+02
6	3	0,00E+00	-1,58E-01	6,50E-01	6,72E-03	5,56E-03	-1,59E-02	6,88E+01	5,84E+01	-1,34E+02	0,00E+00	-9,87E+00	1,77E+02
7	4	0,00E+00	0,00E+00	6,50E-01	1,72E-03	1,22E-03	-1,68E-02	7,15E+01	6,48E+01	-1,78E+02	0,00E+00	0,00E+00	1,80E+02
8	4	0,00E+00	-1,58E-01	6,50E-01	1,63E-03	8,61E-04	-1,59E-02	6,88E+01	5,84E+01	-1,67E+02	0,00E+00	-9,87E+00	1,77E+02

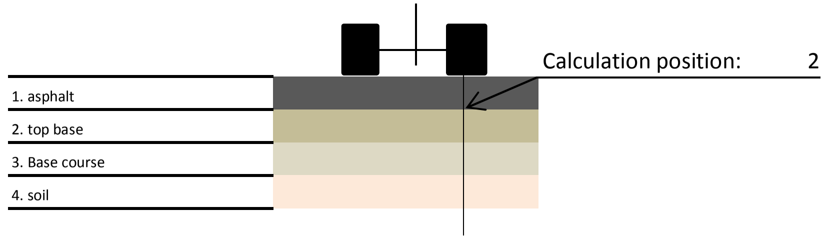
(highlighted) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 5-12-2011

Calculated by: ing. Pascal Lakerveld

Controlled by: ir. Ing. Christophe Egyed



Soil type 4 **Traffic class 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,08	7,50E+03	0,35
2	0,25	6,00E+02	0,35
3	0,3	1,50E+02	0,35
4		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	8,00E-02	7,22E-01	-4,87E-02	-1,43E-01	1,05E+02	-3,35E+01	-5,05E+01	0,00E+00	0,00E+00	3,00E+02
2	1	0,00E+00	-1,58E-01	8,00E-02	1,13E+00	9,36E-01	-2,25E-01	1,18E+02	8,25E+01	-1,27E+02	0,00E+00	-4,49E+00	2,97E+02
3	2	0,00E+00	0,00E+00	3,30E-01	1,01E-01	8,21E-02	-4,48E-02	1,46E+02	1,04E+02	-1,81E+02	0,00E+00	0,00E+00	2,55E+02
4	2	0,00E+00	-1,58E-01	3,30E-01	9,29E-02	7,40E-02	-4,12E-02	1,36E+02	9,31E+01	-1,66E+02	0,00E+00	-1,59E+01	2,45E+02
5	3	0,00E+00	0,00E+00	6,30E-01	7,93E-03	7,00E-03	-1,86E-02	7,99E+01	7,15E+01	-1,59E+02	0,00E+00	0,00E+00	1,89E+02
6	3	0,00E+00	-1,58E-01	6,30E-01	7,49E-03	6,07E-03	-1,75E-02	7,66E+01	6,38E+01	-1,48E+02	0,00E+00	-1,09E+01	1,85E+02
7	4	0,00E+00	0,00E+00	6,30E-01	1,96E-03	1,33E-03	-1,86E-02	7,99E+01	7,15E+01	-1,97E+02	0,00E+00	0,00E+00	1,89E+02
8	4	0,00E+00	-1,58E-01	6,30E-01	1,85E-03	9,06E-04	-1,75E-02	7,66E+01	6,38E+01	-1,85E+02	0,00E+00	-1,09E+01	1,85E+02

(highlighted) = normative value for further calculations (fatique relation)

Appendix 4: Pavement calculation for roads on base of the PowerCem Technology

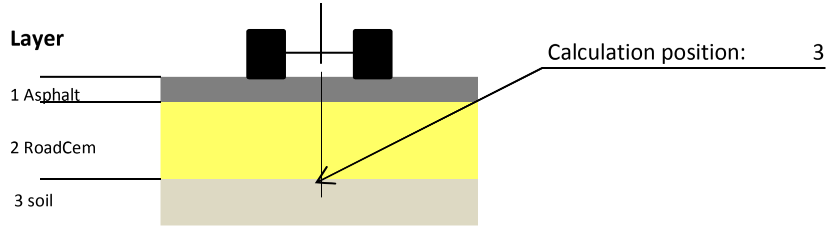
Soil Type	Soil Description	Indicative Quantity of RoadCem	Indicative Quantity of Cement	Mpa	µm/m	formula	Mpa
		(kg/m^3 : MPD) based on requirements imposed within the civil and hydraulic engineering sector	(kg/m^3 : MPD) based on requirements imposed within the civil and hydraulic engineering sector	Compressive strength) 28 days	Breaking strain 28 days	Neq 28 days	E-Modulus 28 days
GW	Clean, well-graded gravels	1.7	170	10-15	300		10000
GP	Clean, poorly graded gravels	1.7	170	6-11	250		6000
GW-GM	Well-graded gravel with silt	1.8	180	10-15	400		10000
GW-GC	Well-graded gravel with clay	2.0	200	10-15	400		10000
GP-GM	Poorly graded gravel with silt	1.8	180	6-11	350		6000
GP-GC	Poorly graded gravel with clay	2.0	200	6-11	350		6000
GM	Silty gravel	1.8	180	6-11	400		6000
GC	Clayey gravel	2.0	200	5-10	450		5000
GC-GM	Silty, clayey gravel	2.0	200	5-10	450		5000
SW	Clean, well-graded sand	1.9	190	8-13	250		8000
SP	Clean, poorly graded sand	1.9	190	6-11	200		6000
SW-SM	Well-graded sand with silt	1.8	180	7-12	350		7000
SW-SC	Well-graded sand with clay	2.0	200	5-10	400		5000
SP-SM	Poorly graded sand with silt	1.8	180	5-10	400		5000
SP-SC	Poorly graded sand with clay	2.0	200	5-8	400		5000
SM	Silty sand	2.0	200	5-8	400		5000
SC	Clayey sand	2.0	200	5-8	450		4000
ML	Inorganic silt with fine sand	2.0	200	5-8	450		5000

Soil Type	Soil Description	Indicative Quantity of RoadCem (kg/m³ : MPD) based on requirements imposed within the civil and hydraulic engineering sector	Indicative Quantity of Cement (kg/m³ : MPD) based on requirements imposed within the civil and hydraulic engineering sector	Mpa	µm/m	formula	Mpa
				Compressive strength) 28 days	Breaking strain 28 days	Neq 28 days	E-Modulus 28 days
CL	Inorganic clay with low plasticity (lean clay)	2.0	200	5-6	500		3500
OL	Organic silt with low plasticity	2.1	210	5-7	450		3500
MH	Inorganic silt with high plasticity (elastic silt)	2.1	210	5-7	450		3000
CH	Inorganic clay with high plasticity (fat clay)	2.2	220	5-7	450		3000
OH	Organic clay with high plasticity (organic silt)	2.2	220	4-6	400		3000
PT	Peat and other highly organic soil	2.4	240	1-3	300		1000

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed

Soil type 1 **Road 1**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,31	3,50E+03	0,25
3		2,50E+01	0,35

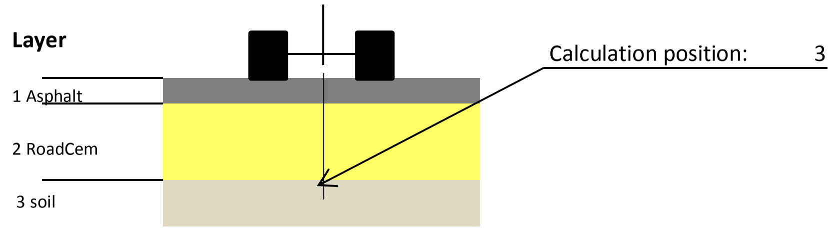
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,57E-01	-5,95E-01	-8,04E-02	-1,61E+01	-5,89E+01	3,37E+01	0,00E+00	0,00E+00	4,72E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-3,35E-01	-3,22E-01	-4,94E-01	-6,54E+00	-4,29E+00	-3,52E+01	0,00E+00	4,08E+00	4,76E+02
3	2	0,00E+00	0,00E+00	3,60E-01	3,45E-01	3,01E-01	-6,85E-03	**7,75E+01**	6,18E+01	-4,81E+01	0,00E+00	0,00E+00	4,63E+02
4	2	0,00E+00	-1,58E-01	3,60E-01	3,27E-01	2,84E-01	-6,61E-03	7,37E+01	5,82E+01	-4,55E+01	0,00E+00	-9,60E+00	4,58E+02
5	3	0,00E+00	0,00E+00	3,60E-01	-8,65E-04	-1,15E-03	-6,85E-03	7,75E+01	6,18E+01	-2,46E+02	0,00E+00	0,00E+00	4,63E+02
6	3	0,00E+00	-1,58E-01	3,60E-01	-8,80E-04	-1,17E-03	-6,61E-03	7,37E+01	5,82E+01	-2,36E+02	0,00E+00	-9,60E+00	4,58E+02

= normative value for further calculations (fatigue related)

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 1 **Road 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,3	3,50E+03	0,25
3		2,50E+01	0,35

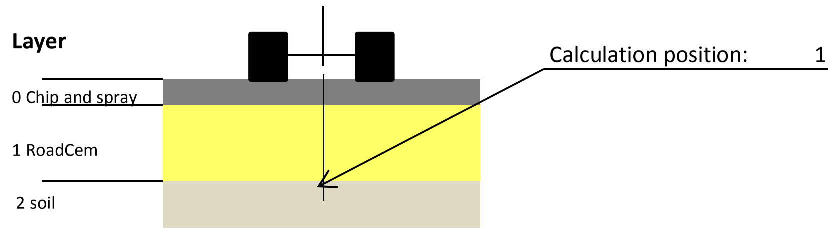
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,65E-01	-6,02E-01	-7,98E-02	-1,69E+01	-5,95E+01	3,45E+01	0,00E+00	0,00E+00	4,84E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-3,42E-01	-3,29E-01	-4,94E-01	-7,25E+00	-4,82E+00	-3,45E+01	0,00E+00	4,17E+00	4,87E+02
3	2	0,00E+00	0,00E+00	3,50E-01	3,61E-01	3,13E-01	-7,19E-03	**8,12E+01**	6,42E+01	-5,02E+01	0,00E+00	0,00E+00	4,75E+02
4	2	0,00E+00	-1,58E-01	3,50E-01	3,43E-01	2,96E-01	-6,94E-03	7,73E+01	6,07E+01	-4,76E+01	0,00E+00	-9,99E+00	4,70E+02
5	3	0,00E+00	0,00E+00	3,50E-01	-9,16E-04	-1,23E-03	-7,19E-03	8,12E+01	6,42E+01	-2,57E+02	0,00E+00	0,00E+00	4,75E+02
6	3	0,00E+00	-1,58E-01	3,50E-01	-9,31E-04	-1,24E-03	-6,94E-03	7,73E+01	6,07E+01	-2,47E+02	0,00E+00	-9,99E+00	4,70E+02

= normative value for further calculations (fatique rel...

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 1 **Road 3**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,33	3,50E+03	0,35
2		2,50E+01	0,35

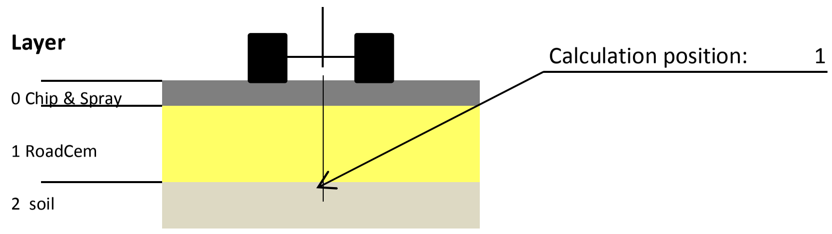
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	3,30E-01	4,78E-01	4,20E-01	-8,95E-03	9,54E+01	7,30E+01	-9,23E+01	0,00E+00	0,00E+00	5,40E+02
2	1	0,00E+00	-1,58E-01	3,30E-01	4,56E-01	4,03E-01	-8,66E-03	9,08E+01	7,03E+01	-8,83E+01	0,00E+00	-1,15E+01	5,33E+02
3	2	0,00E+00	0,00E+00	6,60E-01	-7,21E-04	-7,83E-04	-5,91E-03	6,49E+01	6,16E+01	-2,15E+02	0,00E+00	0,00E+00	4,55E+02
4	2	0,00E+00	-1,58E-01	6,60E-01	-7,18E-04	-8,17E-04	-5,77E-03	6,35E+01	5,82E+01	-2,09E+02	0,00E+00	-9,52E+00	4,51E+02

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 1 **Road 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,31	3,50E+03	0,35
2		2,50E+01	0,35

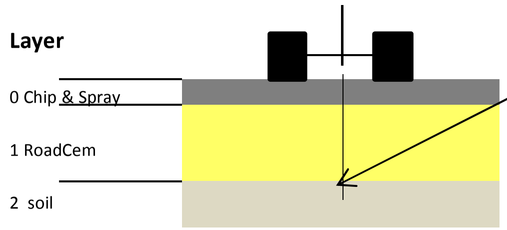
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	3,10E-01	5,27E-01	4,58E-01	-9,98E-03	1,06E+02	7,90E+01	-1,01E+02	0,00E+00	0,00E+00	5,73E+02
2	1	0,00E+00	-1,58E-01	3,10E-01	5,05E-01	4,44E-01	-9,67E-03	1,01E+02	7,74E+01	-9,76E+01	0,00E+00	-1,25E+01	5,66E+02
3	2	0,00E+00	0,00E+00	6,40E-01	-7,83E-04	-8,54E-04	-6,53E-03	7,20E+01	6,82E+01	-2,38E+02	0,00E+00	0,00E+00	4,79E+02
4	2	0,00E+00	-1,58E-01	6,40E-01	-7,78E-04	-8,93E-04	-6,36E-03	7,04E+01	6,42E+01	-2,31E+02	0,00E+00	-1,05E+01	4,75E+02

(yellow) = normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 1 **Road 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,29	3,50E+03	0,35
2		2,50E+01	0,35

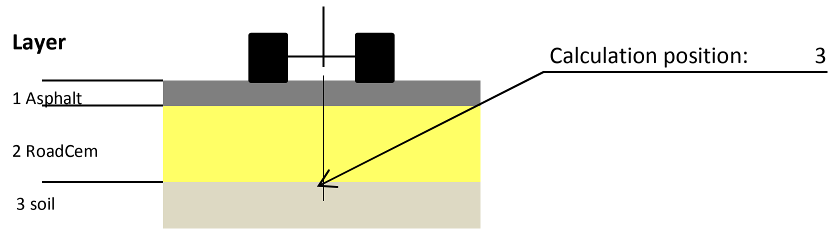
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,90E-01	5,84E-01	5,00E-01	-1,12E-02	1,18E+02	8,57E+01	-1,12E+02	0,00E+00	0,00E+00	6,11E+02
2	1	0,00E+00	-1,58E-01	2,90E-01	5,62E-01	4,93E-01	-1,09E-02	1,12E+02	8,57E+01	-1,09E+02	0,00E+00	-1,37E+01	6,02E+02
3	2	0,00E+00	0,00E+00	6,20E-01	-8,51E-04	-9,35E-04	-7,24E-03	8,04E+01	7,59E+01	-2,65E+02	0,00E+00	0,00E+00	5,05E+02
4	2	0,00E+00	-1,58E-01	6,20E-01	-8,45E-04	-9,79E-04	-7,05E-03	7,86E+01	7,13E+01	-2,56E+02	0,00E+00	-1,17E+01	5,01E+02

= normative value for further calculations (fatique rel

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soil type 2 **Road 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,28	3,50E+03	0,25
3		5,00E+01	0,35

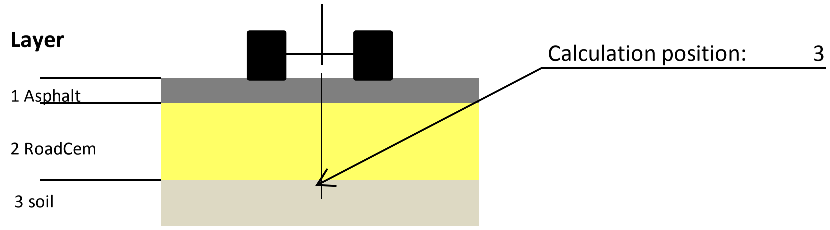
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,30E-01	-5,65E-01	-7,88E-02	-1,39E+01	-5,63E+01	3,13E+01	0,00E+00	0,00E+00	3,22E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-3,06E-01	-2,92E-01	-4,93E-01	-4,22E+00	-1,59E+00	-3,78E+01	0,00E+00	3,67E+00	3,25E+02
3	2	0,00E+00	0,00E+00	3,30E-01	3,45E-01	2,90E-01	-1,24E-02	**7,88E+01**	5,91E+01	-4,89E+01	0,00E+00	0,00E+00	3,14E+02
4	2	0,00E+00	-1,58E-01	3,30E-01	3,27E-01	2,76E-01	-1,19E-02	7,46E+01	5,64E+01	-4,65E+01	0,00E+00	-9,25E+00	3,09E+02
5	3	0,00E+00	0,00E+00	3,30E-01	-1,01E-03	-1,74E-03	-1,24E-02	7,88E+01	5,91E+01	-2,29E+02	0,00E+00	0,00E+00	3,14E+02
6	3	0,00E+00	-1,58E-01	3,30E-01	-1,05E-03	-1,72E-03	-1,19E-02	7,46E+01	5,64E+01	-2,19E+02	0,00E+00	-9,25E+00	3,09E+02

= normative value for further calculations (fatique re

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 2 **Road 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,27	3,50E+03	0,25
3		5,00E+01	0,35

Load Number	Load Vertical (kN)	Stress Vertical (MPa)	Load Horz. (Shear) (kN)	Stress Horz. (Shear) (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Angle Shear (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

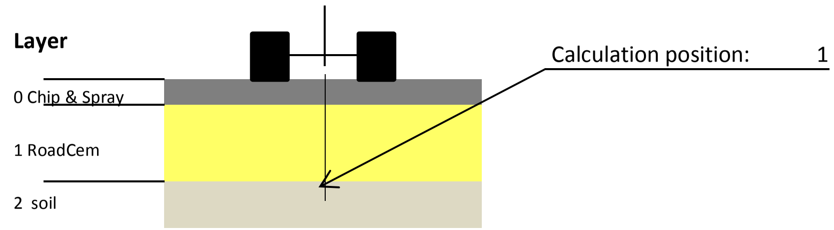
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,36E-01	-5,71E-01	-7,80E-02	-1,46E+01	-5,68E+01	3,19E+01	0,00E+00	0,00E+00	3,31E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-3,12E-01	-2,96E-01	-4,92E-01	-4,82E+00	-2,00E+00	-3,72E+01	0,00E+00	3,74E+00	3,34E+02
3	2	0,00E+00	0,00E+00	3,20E-01	3,62E-01	3,02E-01	-1,31E-02	**8,28E+01**	6,13E+01	-5,11E+01	0,00E+00	0,00E+00	3,23E+02
4	2	0,00E+00	-1,58E-01	3,20E-01	3,44E-01	2,89E-01	-1,26E-02	7,84E+01	5,90E+01	-4,88E+01	0,00E+00	-9,63E+00	3,18E+02
5	3	0,00E+00	0,00E+00	3,20E-01	-1,09E-03	-1,88E-03	-1,31E-02	8,28E+01	6,13E+01	-2,40E+02	0,00E+00	0,00E+00	3,23E+02
6	3	0,00E+00	-1,58E-01	3,20E-01	-1,12E-03	-1,84E-03	-1,26E-02	7,84E+01	5,90E+01	-2,30E+02	0,00E+00	-9,63E+00	3,18E+02

= normative value for further calculations (fatique rela

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed

Soiltype 2 **Road 3**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,3	3,50E+03	0,35
2		5,00E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

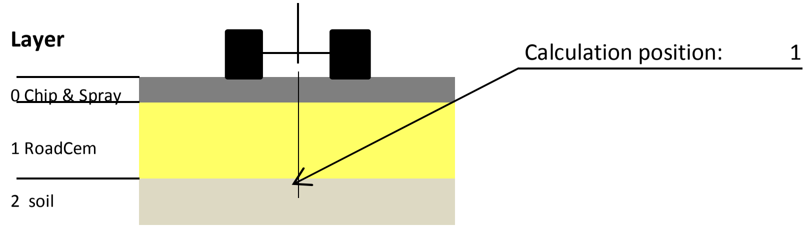
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	3,00E-01	4,78E-01	4,03E-01	-1,63E-02	9,78E+01	6,91E+01	-9,28E+01	0,00E+00	0,00E+00	3,68E+02
2	1	0,00E+00	-1,58E-01	3,00E-01	4,57E-01	3,95E-01	-1,57E-02	9,27E+01	6,86E+01	-8,96E+01	0,00E+00	-1,10E+01	3,62E+02
3	2	0,00E+00	0,00E+00	6,30E-01	-7,82E-04	-9,26E-04	-9,75E-03	5,91E+01	5,52E+01	-1,83E+02	0,00E+00	0,00E+00	2,92E+02
4	2	0,00E+00	-1,58E-01	6,30E-01	-7,77E-04	-1,01E-03	-9,44E-03	5,76E+01	5,14E+01	-1,76E+02	0,00E+00	-8,50E+00	2,89E+02

= normative value for further calculations (fatigue re

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed

Soiltype 2 **Road 4**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,28	3,50E+03	0,35
2		5,00E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,80E-01	5,29E-01	4,39E-01	-1,83E-02	1,09E+02	7,43E+01	-1,02E+02	0,00E+00	0,00E+00	3,93E+02
2	1	0,00E+00	-1,58E-01	2,80E-01	5,09E-01	4,38E-01	-1,77E-02	1,03E+02	7,59E+01	-9,97E+01	0,00E+00	-1,20E+01	3,85E+02
3	2	0,00E+00	0,00E+00	6,10E-01	-8,41E-04	-1,01E-03	-1,08E-02	6,58E+01	6,12E+01	-2,03E+02	0,00E+00	0,00E+00	3,08E+02
4	2	0,00E+00	-1,58E-01	6,10E-01	-8,35E-04	-1,10E-03	-1,04E-02	6,39E+01	5,68E+01	-1,95E+02	0,00E+00	-9,40E+00	3,04E+02

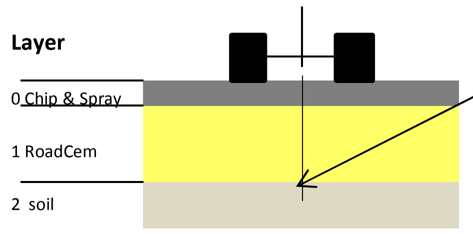
= normative value for further calculations (fatique rela

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011

Calculated by: ir. Ing. Christophe Egyed

Controlled by: ir. Ing. Christophe Egyed



Soiltype 2 **Road 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,26	3,50E+03	0,35
2		5,00E+01	0,35

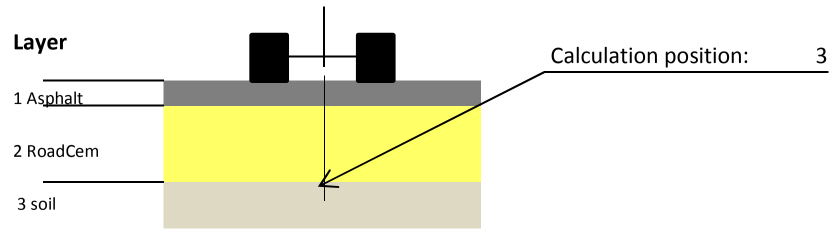
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,60E-01	5,88E-01	4,78E-01	-2,06E-02	1,22E+02	7,99E+01	-1,13E+02	0,00E+00	0,00E+00	4,20E+02
2	1	0,00E+00	-1,58E-01	2,60E-01	5,71E-01	4,89E-01	-2,01E-02	1,16E+02	8,45E+01	-1,12E+02	0,00E+00	-1,32E+01	4,11E+02
3	2	0,00E+00	0,00E+00	5,90E-01	-9,05E-04	-1,11E-03	-1,20E-02	7,36E+01	6,82E+01	-2,26E+02	0,00E+00	0,00E+00	3,25E+02
4	2	0,00E+00	-1,58E-01	5,90E-01	-8,96E-04	-1,21E-03	-1,16E-02	7,15E+01	6,30E+01	-2,17E+02	0,00E+00	-1,05E+01	3,21E+02

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soil type 3 **Road 1**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,26	3,50E+03	0,25
3		7,50E+01	0,35

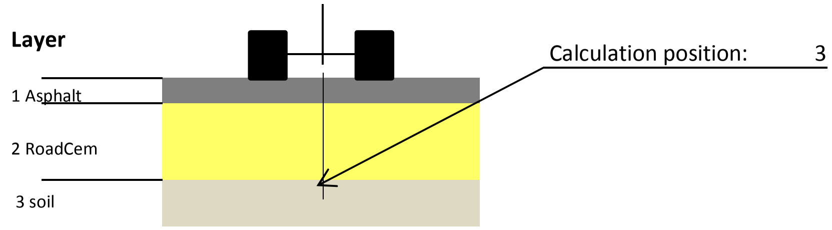
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,11E-01	-5,45E-01	-7,76E-02	-1,24E+01	-5,45E+01	2,96E+01	0,00E+00	0,00E+00	2,59E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-2,87E-01	-2,71E-01	-4,92E-01	-2,65E+00	2,17E-01	-3,95E+01	0,00E+00	3,39E+00	2,62E+02
3	2	0,00E+00	0,00E+00	3,10E-01	3,45E-01	2,81E-01	-1,77E-02	**7,98E+01**	5,68E+01	-4,97E+01	0,00E+00	0,00E+00	2,52E+02
4	2	0,00E+00	-1,58E-01	3,10E-01	3,27E-01	2,71E-01	-1,70E-02	7,53E+01	5,52E+01	-4,76E+01	0,00E+00	-8,98E+00	2,47E+02
5	3	0,00E+00	0,00E+00	3,10E-01	-1,00E-03	-2,28E-03	-1,77E-02	7,98E+01	5,68E+01	-2,21E+02	0,00E+00	0,00E+00	2,52E+02
6	3	0,00E+00	-1,58E-01	3,10E-01	-1,05E-03	-2,17E-03	-1,70E-02	7,53E+01	5,52E+01	-2,11E+02	0,00E+00	-8,98E+00	2,47E+02

= normative value for further calculations (fatique re

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 3 **Road 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,25	3,50E+03	0,25
3		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

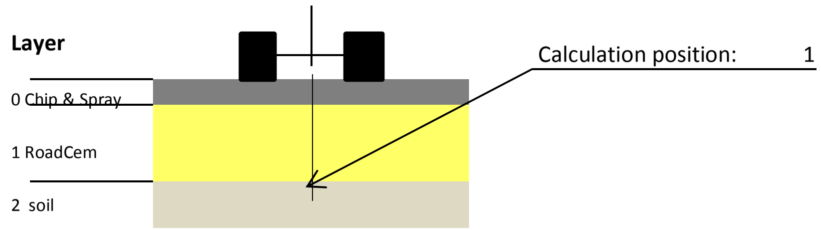
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-3,16E-01	-5,50E-01	-7,67E-02	-1,30E+01	-5,49E+01	3,02E+01	0,00E+00	0,00E+00	2,67E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-2,92E-01	-2,75E-01	-4,91E-01	-3,16E+00	-9,08E-02	-3,90E+01	0,00E+00	3,45E+00	2,69E+02
3	3	0,00E+00	0,00E+00	3,10E-01	-1,08E-03	-2,37E-03	-1,82E-02	**8,17E+01**	5,86E+01	-2,27E+02	0,00E+00	0,00E+00	2,57E+02
4	3	0,00E+00	-1,58E-01	3,10E-01	-1,13E-03	-2,26E-03	-1,75E-02	7,71E+01	5,67E+01	-2,17E+02	0,00E+00	-9,24E+00	2,52E+02
5	3	0,00E+00	0,00E+00	3,10E-01	-1,08E-03	-2,37E-03	-1,82E-02	8,17E+01	5,86E+01	-2,27E+02	0,00E+00	0,00E+00	2,57E+02
6	3	0,00E+00	-1,58E-01	3,10E-01	-1,13E-03	-2,26E-03	-1,75E-02	7,71E+01	5,67E+01	-2,17E+02	0,00E+00	-9,24E+00	2,52E+02

= normative value for further calculations (fatigue rela

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed

Soiltype 3 **Road 3**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,28	3,50E+03	0,35
2		7,50E+01	0,35

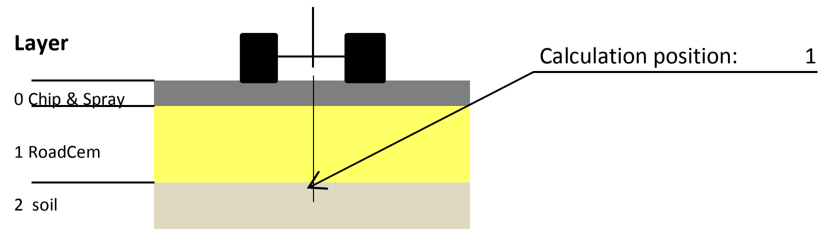
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,60E-01	3,89E-01	3,21E-01	-2,69E-02	8,18E+01	5,55E+01	-7,87E+01	0,00E+00	0,00E+00	2,98E+02
2	1	0,00E+00	-1,58E-01	2,60E-01	3,70E-01	3,15E-01	-2,94E-02	7,73E+01	5,58E+01	-7,69E+01	0,00E+00	-8,92E+00	2,91E+02
3	2	0,00E+00	0,00E+00	5,90E-01	-7,90E-04	-1,05E-03	-1,34E-02	5,70E+01	5,23E+01	-1,70E+02	0,00E+00	0,00E+00	2,29E+02
4	2	0,00E+00	-1,58E-01	5,90E-01	-7,86E-04	-1,19E-03	-1,29E-02	5,52E+01	4,80E+01	-1,63E+02	0,00E+00	-8,01E+00	2,25E+02

= normative value for further calculations (fatique re

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soiltype 3 **Road 4**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,26	3,50E+03	0,35
2		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,60E-01	5,28E-01	4,20E-01	-2,62E-02	1,11E+02	6,99E+01	-1,02E+02	0,00E+00	0,00E+00	3,17E+02
2	1	0,00E+00	-1,58E-01	2,60E-01	5,12E-01	4,33E-01	-2,55E-02	1,06E+02	7,50E+01	-1,02E+02	0,00E+00	-1,16E+01	3,09E+02
3	2	0,00E+00	0,00E+00	5,90E-01	-7,81E-04	-1,06E-03	-1,44E-02	6,19E+01	5,68E+01	-1,84E+02	0,00E+00	0,00E+00	2,37E+02
4	2	0,00E+00	-1,58E-01	5,90E-01	-7,76E-04	-1,21E-03	-1,38E-02	5,98E+01	5,20E+01	-1,75E+02	0,00E+00	-8,69E+00	2,34E+02

= normative value for further calculations (fatigue rela

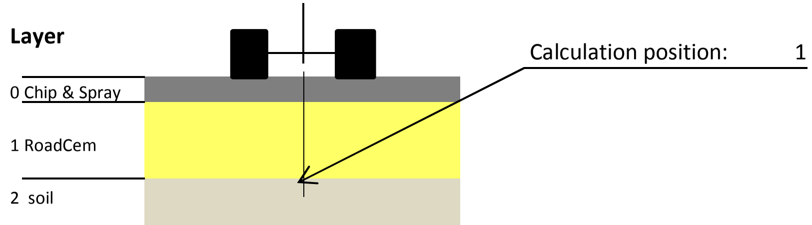
Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011

Calculated by: ir. Ing. Christophe Egyed

Controlled by: ir. Ing. Christophe Egyed

Soiltype 3 **Road 5**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,24	3,50E+03	0,35
2		7,50E+01	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

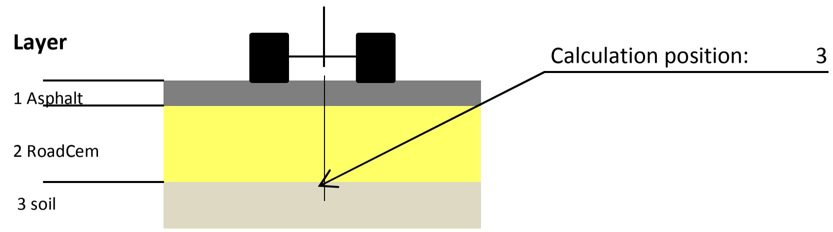
Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,40E-01	5,87E-01	4,56E-01	-2,97E-02	1,25E+02	7,44E+01	-1,13E+02	0,00E+00	0,00E+00	3,40E+02
2	1	0,00E+00	-1,58E-01	2,40E-01	5,77E-01	4,85E-01	-2,91E-02	1,19E+02	8,39E+01	-1,15E+02	0,00E+00	-1,27E+01	3,31E+02
3	2	0,00E+00	0,00E+00	5,70E-01	-8,26E-04	-1,17E-03	-1,61E-02	6,94E+01	6,33E+01	-2,05E+02	0,00E+00	0,00E+00	2,51E+02
4	2	0,00E+00	-1,58E-01	5,70E-01	-8,17E-04	-1,33E-03	-1,54E-02	6,70E+01	5,77E+01	-1,95E+02	0,00E+00	-9,67E+00	2,46E+02

= normative value for further calculations (fatique relation)

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed

Soil type 4 **Road 1**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,25	3,50E+03	0,25
3		1,00E+02	0,35

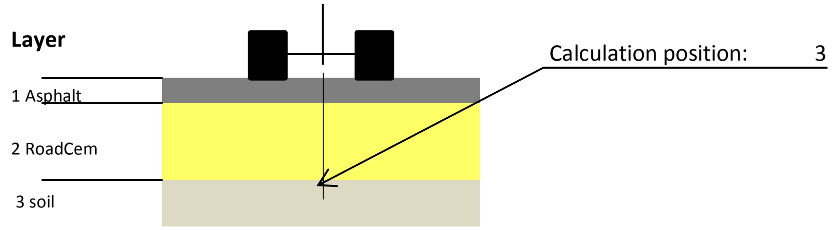
Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-2,93E-01	-5,27E-01	-7,71E-02	-1,09E+01	-5,30E+01	2,80E+01	0,00E+00	0,00E+00	2,20E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-2,69E-01	-2,53E-01	-4,91E-01	-1,16E+00	1,76E+00	-4,11E+01	0,00E+00	3,15E+00	2,23E+02
3	2	0,00E+00	0,00E+00	3,00E-01	3,35E-01	2,66E-01	-2,22E-02	**7,84E+01**	5,36E+01	-4,93E+01	0,00E+00	0,00E+00	2,12E+02
4	2	0,00E+00	-1,58E-01	3,00E-01	3,18E-01	2,60E-01	-2,13E-02	7,38E+01	5,30E+01	-4,73E+01	0,00E+00	-8,55E+00	2,08E+02
5	3	0,00E+00	0,00E+00	3,00E-01	-8,65E-04	-2,70E-03	-2,22E-02	7,84E+01	5,36E+01	-2,09E+02	0,00E+00	0,00E+00	2,12E+02
6	3	0,00E+00	-1,58E-01	3,00E-01	-9,37E-04	-2,48E-03	-2,13E-02	7,38E+01	5,30E+01	-2,01E+02	0,00E+00	-8,55E+00	2,08E+02

= normative value for further calculations (fatique re

Project: **Unesco - Floods Tabasco**

Calculated: 22-11-2011
Calculated by: ir. Ing. Christophe Egyed
Controlled by: ir. Ing. Christophe Egyed



Soil type 4 **Road 2**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,05	7,50E+03	0,35
2	0,24	3,50E+03	0,25
3		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	5,00E-02	-2,98E-01	-5,31E-01	-7,62E-02	-1,14E+01	-5,33E+01	2,85E+01	0,00E+00	0,00E+00	2,26E+02
2	1	0,00E+00	-1,58E-01	5,00E-02	-2,73E-01	-2,56E-01	-4,90E-01	-1,60E+00	1,52E+00	-4,07E+01	0,00E+00	3,19E+00	2,29E+02
3	2	0,00E+00	0,00E+00	2,90E-01	3,52E-01	2,76E-01	-2,33E-02	**8,25E+01**	5,54E+01	-5,15E+01	0,00E+00	0,00E+00	2,19E+02
4	2	0,00E+00	-1,58E-01	2,90E-01	3,35E-01	2,72E-01	-2,25E-02	7,77E+01	5,55E+01	-4,98E+01	0,00E+00	-8,89E+00	2,14E+02
5	3	0,00E+00	0,00E+00	2,90E-01	-9,54E-04	-2,96E-03	-2,33E-02	8,25E+01	5,54E+01	-2,20E+02	0,00E+00	0,00E+00	2,19E+02
6	3	0,00E+00	-1,58E-01	2,90E-01	-1,02E-03	-2,66E-03	-2,25E-02	7,77E+01	5,55E+01	-2,12E+02	0,00E+00	-8,89E+00	2,14E+02

= normative value for further calculations (fatique rela

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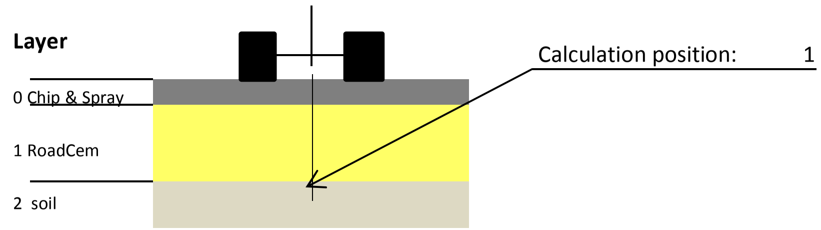
Soil type 4 **Road 3**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,27	3,50E+03	0,35
2		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,70E-01	4,60E-01	3,65E-01	-2,92E-02	9,79E+01	6,11E+01	-9,08E+01	0,00E+00	0,00E+00	2,50E+02
2	1	0,00E+00	-1,58E-01	2,70E-01	4,44E-01	3,73E-01	-2,83E-02	9,25E+01	6,49E+01	-8,98E+01	0,00E+00	-1,01E+01	2,44E+02
3	2	0,00E+00	0,00E+00	6,00E-01	-6,33E-04	-9,62E-04	-1,55E-02	5,14E+01	4,70E+01	-1,50E+02	0,00E+00	0,00E+00	1,84E+02
4	2	0,00E+00	-1,58E-01	6,00E-01	-6,30E-04	-1,14E-03	-1,49E-02	4,97E+01	4,29E+01	-1,42E+02	0,00E+00	-7,18E+00	1,81E+02

= normative value for further calculations (fatique re

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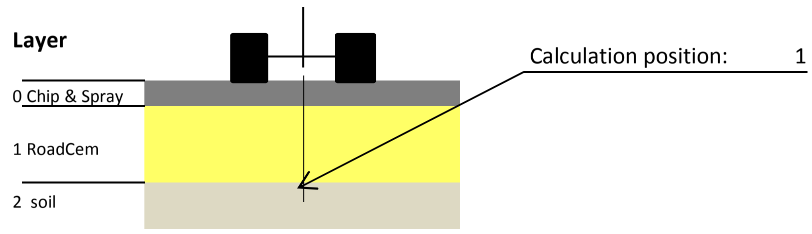
Soil type 4 **Road 4**



Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,25	3,50E+03	0,35
2		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,50E-01	5,09E-01	3,93E-01	-3,28E-02	1,10E+02	6,47E+01	-9,96E+01	0,00E+00	0,00E+00	2,68E+02
2	1	0,00E+00	-1,58E-01	2,50E-01	4,98E-01	4,16E-01	-3,20E-02	1,04E+02	7,22E+01	-1,01E+02	0,00E+00	-1,10E+01	2,60E+02
3	2	0,00E+00	0,00E+00	5,80E-01	-6,63E-04	-1,05E-03	-1,72E-02	5,72E+01	5,19E+01	-1,66E+02	0,00E+00	0,00E+00	1,94E+02
4	2	0,00E+00	-1,58E-01	5,80E-01	-6,60E-04	-1,25E-03	-1,64E-02	5,52E+01	4,72E+01	-1,57E+02	0,00E+00	-7,93E+00	1,91E+02

= normative value for further calculations (fatigue rela

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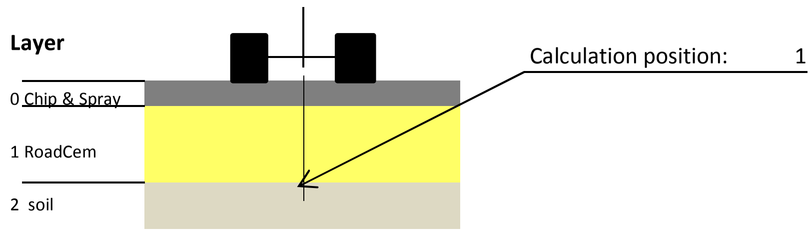

Soil type 4 **Road 5**

Layer	Thickness (m)	Elasticity Modulus (MPa)	Poisson's Ratio
1	0,23	3,50E+03	0,35
2		1,00E+02	0,35

Load Number	Vertical Load (kN)	Vertical Stress (MPa)	Horz. (Shear) Load (kN)	Horz. (Shear) Stress (MPa)	Radius (m)	X-Coordinate (m)	Y-Coordinate (m)	Shear Angle (Degrees)
1	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	-1,58E-01	0,00E+00
2	2,00E+01	5,77E-01	0,00E+00	0,00E+00	1,05E-01	0,00E+00	1,58E-01	0,00E+00

Position	Layer Number	X-Coordinate (m)	Y-Coordinate (m)	Depth (m)	XX Stress (MPa)	YY Stress (MPa)	ZZ Stress (MPa)	XX Strain µstrain	YY Strain µstrain	ZZ Strain µstrain	UX Displacement (µm)	UY Displacement (µm)	UZ Displacement (µm)
1	1	0,00E+00	0,00E+00	2,30E-01	5,67E-01	4,24E-01	-3,71E-02	1,23E+02	6,81E+01	-1,10E+02	0,00E+00	0,00E+00	2,88E+02
2	1	0,00E+00	-1,58E-01	2,30E-01	5,62E-01	4,67E-01	-3,66E-02	1,18E+02	8,09E+01	-1,13E+02	0,00E+00	-1,19E+01	2,79E+02
3	2	0,00E+00	0,00E+00	5,60E-01	-6,86E-04	-1,15E-03	-1,91E-02	6,41E+01	5,78E+01	-1,85E+02	0,00E+00	0,00E+00	2,05E+02
4	2	0,00E+00	-1,58E-01	5,60E-01	-6,80E-04	-1,38E-03	-1,82E-02	6,17E+01	5,22E+01	-1,75E+02	0,00E+00	-8,80E+00	2,01E+02

= normative value for further calculations (fatique relation)

Appendix 5: Cost calculations Traditional constructions

Step 1: Excavation and preparation

After a flood the destroyed road have to be cleaned from left overs and other washed material. The trace has to be excavated or filled up.
The costs are strongly depending per situation. For this study are the average costs estimated on base of expert judgment.

In table 3.1 is a calculation made for the preparation costs of 1m3.

1 EXCAVATION / PREPARATION OF THE SITE				
Labor (description):	**AMOUNT**	**UNIT**	**SALARY**	**COST IN MEXICAN PESOS**
Crew No. 1 (1.00 Assistant)		wage		
Assistant	*1,00000*	*wage*	*$ 294,05*	*$ 294,05*
Specialized foreman (cape)	*0,20000*	*wage*	*$ 949,47*	*$ 189,89*
Minor tools	*0,03000*	*(%)labor*	*$ 483,94*	*$ 14,52*
Factor of safety equipment	*0,05000*	*(%)labor*	*$ 483,94*	*$ 24,20*
			addition	*$ 522,66*
EFFICIENCY	80,00000			
COST IN MEXICAN PESOS for labor [m^3]:				**$ 6,53**

Equipment (DESCRIPTION):	**AMOUNT**	**UNIT**	**RENT**	**COST IN MEXICAN PESOS**
Excavator, Caterpillar 350L	0,02500	hour	$ 1.200,00	$ 30,00
COST IN MEXICAN PESOS FOR EQUIPMENT [m^3]				**$ 30,00**

TOTAL COSTS		
Direct cost		$ 36,53
Indirect	6,47%	$ 2,36
Field indirect	4,00%	$ 1,46
Subtotal		$ 40,36
Funding	0,25%	$ 0,09
Subtotal		$ 38,03
Utility	10,53%	$ 4,00
Additional Charges	0,50%	$ 0,19
UNITARY COST[m^3]		**$ 42,22**

Table 1: Unitary costs step 1

Depending of the thickness of the RoadCem cement layer construction will the price per m^2 calculated. In table 2 are the costs for the preparation per construction summarized:

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Roadtype 1: Highways	$ 40,96	$ 40,54	$ 29,98	$ 29,98
Roadtype 2: Primary roads	$ 40,11	$ 40,11	$ 29,56	$ 29,56
Roadtype 3: Secondary roads	$ 39,27	$ 39,27	$ 28,71	$ 28,71
Roadtype 4: Rural roads	$ 38,00	$ 38,00	$ 27,45	$ 27,45
Roadtype 5: Access roads	$ 37,16	$ 37,16	$ 26,60	$ 26,60

Table 2: Summarized construction costs step 1. Given costs are per m2 in Mexican Pesos

Step 2: Leveling and pre-compaction

The second step is leveling and compaction of the trace. This have to be done prior to the further steps for a fast processing of the further layers. The extended calculations are given in table 3.16:

2 PRECOMPACTION OF THE SOIL				
Materials (DESCRIPTION):	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Water pipe (not potable)	0,03000	m3	$ 50,00	$ 1,50
COST IN MEXICAN PESOS FOR Materials				**$ 1,50**

Labor (description):	AMOUNT	UNIT	SALARIO	COST IN MEXICAN PESOS
Crew No. 1 (1.00 Assistant)		wage		
Assistant	*1,00000*	*wage*	*$ 294,05*	*$ 294,05*
Specialized foreman (cape)	*0,20000*	*wage*	*$ 949,47*	*$ 189,89*
Minor tools	*0,03000*	*(%)labor*	*$ 483,94*	*$ 14,52*
Factor of safety equipment	*0,05000*	*(%)labor*	*$ 483,94*	*$ 24,20*
			addition	*$ 522,66*
EFFICIENCY	400,00000			
COST IN MEXICAN PESOS for labor:				**$ 1,31**

Equipment (DESCRIPTION):	AMOUNT	UNIT	RENT	COST IN MEXICAN PESOS
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	0,01000	hora	$ 442,42	$ 4,42
COST IN MEXICAN PESOS FOR EQUIPMENT				**$ 4,42**

TOTAL COSTS		
Direct cost		$ 7,23
Indirect	6,47%	$ 0,47
Field indirect	4,00%	$ 0,29
Subtotal		$ 7,98
Funding	0,25%	$ 0,02
Subtotal		$ 8,00
Utility	10,53%	$ 0,84
Additional Charges	0,50%	$ 0,04
UNITARY COST[M2]		**$ 8,89**

Table 3: Unitary costs step2

Step 3: Applying of the Sub-grad

Depending of the type of soil is a sub-grade required to improve the bearing capacity.

3 APPLYING OF THE SUB-GRADE				
Subgrade material	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Subgrade material	*1,00000*	*m3*	*$ 157,00*	*$ 157,00*
Water pipe (not potable)	*0,10000*	*m3*	*$ 50,00*	*$ 5,00*
Crew No 27 (1.00 Oficial + 7 laborer)	*0,00444*	*wage*	*$ 2.948,05*	*$ 13,09*
Grader 14-H, de 215 hp, motor CAT 3306	*0,10000*	*hour*	*$ 788,87*	*$ 78,89*
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	*0,10000*	*hour*	*$ 442,42*	*$ 44,24*
			addition	*$ 298,22*
COSTS IN MEXICAN PESOS FOR CONSTRUCTION				**$ 298,22**

Survey:	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Topography basic with equipment.		m2		
Lime	*0,00500*	*bulto*	*$ 29,00*	*$ 0,14*
Bar / stakes	*0,01500*	*pza.*	*$ 5,00*	*$ 0,08*
electric transit Includes topographer and rodman	*0,01000*	*hora*	*$ 340,89*	*$ 3,41*
			addition	*$ 3,64*
AMOUNT	4,00000			
COST IN MEXICAN PESOS for Survey				**$ 14,56**

TOTAL COSTS		
Direct cost		$ 312,78
Indirect	6,47%	$ 20,24
Field indirect	4,00%	$ 12,51
Subtotal		$ 345,53
Funding	0,25%	$ 0,86
Subtotal		$ 346,39
Utility	10,53%	$ 36,47
Additional Charges	0,50%	$ 1,73
UNITARY COST [M3]		**$ 384,60**

Table 4: Unitary costs step3

The costs per construction are summarized in table 3.18.

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Roadtype 1: Highways	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Roadtype 2: Primary roads	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Roadtype 3: Secondary roads	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Roadtype 4: Rural roads	$ 115,38	$ 115,38	$ 0,00	$ 0,00
Roadtype 5: Access roads	$ 115,38	$ 115,38	$ 0,00	$ 0,00

Table 5: Summarized construction costs step 3 in Mexican Pesos per m^2

Step 4: Applying of the Sub-base

4 APPLYING OF THE SUB-BASE				
Subgrade material	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Subbase material	*1,00000*	*m3*	*$ 157,00*	*$ 157,00*
Water pipe (not potable)	*0,10000*	*m3*	*$ 50,00*	*$ 5,00*
Crew No 27 (1.00 Oficial + 7 laborer)	*0,00444*	*wage*	*$ 2.948,05*	*$ 13,09*
Grader 14-H, de 215 hp, motor CAT 3306	*0,10000*	*hour*	*$ 788,87*	*$ 78,89*
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	*0,10000*	*hour*	*$ 442,42*	*$ 44,24*
			addition	*$ 298,22*
AMOUNT	1,00000			
COSTS IN MEXICAN PESOS FOR CONSTRUCTION				**$ 298,22**

Survey:	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Topography basic with equipment.		m2		
Lime	*0,00500*	*bulto*	*$ 29,00*	*$ 0,14*
Bar / stakes	*0,01500*	*pza.*	*$ 5,00*	*$ 0,08*
electric transit Includes topographer and rodman	*0,01000*	*hora*	*$ 340,89*	*$ 3,41*
			addition	*$ 3,64*
AMOUNT	4,00000			
COST IN MEXICAN PESOS for Survey				**$ 14,56**

TOTAL COSTS		
Direct cost		$ 312,78
Indirect	6,47%	$ 20,24
Field indirect	4,00%	$ 12,51
Subtotal		$ 345,53
Funding	0,25%	$ 0,86
Subtotal		$ 346,39
Utility	10,53%	$ 36,47
Additional Charges	0,50%	$ 1,73
UNITARY COST [M3]		**$ 384,60**

Table 6: Unitary costs step4

The costs per construction are summarized in the following table.

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Roadtype 1: Highways	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Roadtype 2: Primary roads	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Roadtype 3: Secondary roads	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Roadtype 4: Rural roads	$ 96,15	$ 96,15	$ 115,38	$ 115,38
Roadtype 5: Access roads	$ 96,15	$ 96,15	$ 115,38	$ 115,38

Table 7: Summarized construction costs step 4 in Mexican Pesos per m^2

Step 5: Applying of the Base course

5 APPLYING OF THE BASE-COURSE				
Subgrade material	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
basecourse material	*1,00000*	*m3*	*$ 180,00*	*$ 180,00*
Water pipe (not potable)	*0,10000*	*m3*	*$ 50,00*	*$ 5,00*
Crew No 27 (1.00 Oficial + 7 laborer)	*0,00444*	*wage*	*$ 2.948,05*	*$ 13,09*
Grader 14-H, de 215 hp, motor CAT 3306	*0,10000*	*hour*	*$ 788,87*	*$ 78,89*
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	*0,10000*	*hour*	*$ 442,42*	*$ 44,24*
			addition	*$ 321,22*
AMOUNT	1,00000			
COSTS IN MEXICAN PESOS FOR CONSTRUCTION				**$ 321,22**

Survey:	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Topography basic with equipment.		m2		
Lime	*0,00500*	*bulto*	*$ 29,00*	*$ 0,14*
Bar / stakes	*0,01500*	*pza.*	*$ 5,00*	*$ 0,08*
electric transit Includes topographer and rodman	*0,01000*	*hora*	*$ 340,89*	*$ 3,41*
			addition	*$ 3,64*
AMOUNT	4,00000			
COST IN MEXICAN PESOS for Survey				**$ 14,56**

TOTAL COSTS		
Direct cost		$ 335,78
Indirect	6,47%	$ 21,72
Field indirect	4,00%	$ 13,43
Subtotal		$ 370,93
Funding	0,25%	$ 0,93
Subtotal		$ 371,86
Utility	10,53%	$ 39,16
Additional Charges	0,50%	$ 1,86
UNITARY COST[M3]		**$ 412,88**

Table 8: Unitary costs step 5

The costs per construction are summarized in table 3.22.

	Soil type 1: Organic clays	**Soil type 2: Clay**	**Soil type 3: Sandy clay**	**Soil type 4: Sand**
Roadtype 1: Highways	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Roadtype 2: Primary roads	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Roadtype 3: Secondary roads	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Roadtype 4: Rural roads	$ 103,22	$ 103,22	$ 103,22	$ 103,22
Roadtype 5: Access roads	$ 103,22	$ 103,22	$ 103,22	$ 103,22

Table 9: Summarized construction costs step 5 in Mexican Pesos per m^2

Step 6: Applying of the wearing course

The wearing course of the traditional construction exists of asphalt. The thickness of the asphalt layer is depending of the expected amount of traffic. In table 3.23 are the costs of the wearing course per layer extended.

	Soil type 1: Organic clays	**Soil type 2: Clay**	**Soil type 3: Sandy clay**	**Soil type 4: Sand**
Roadtype 1: Highways	$ 1.436,50	$ 1.352,00	$ 1.352,00	$ 1.352,00
Roadtype 2: Primary roads	$ 1.267,50	$ 1.267,50	$ 1.267,50	$ 1.267,50
Roadtype 3: Secondary roads	$ 1.098,50	$ 1.098,50	$ 1.098,50	$ 1.098,50
Roadtype 4: Rural roads	$ 845,00	$ 845,00	$ 845,00	$ 845,00
Roadtype 5: Access roads	$ 676,00	$ 676,00	$ 676,00	$ 676,00

Table 10: Summarized construction costs step 6 in Mexican Pesos per m^2

Appendix 6: Cost calculations RoadCem constructions

Step 1: Scarifying, excavation and preparation

Depending of the situation the location have to be prepared. For the RoadCem construction is assumed that the soil or existing pavement needs a pretreatment for a depth of the thickness of the RoadCem-cement layer.

In table 3.29 is a calculation made for the preparation costs of 1m^3.

Labor (description):	AMOUNT	UNIT	SALARY	COST IN MEXICAN PESOS
Crew No. 1 (1.00 Assistant)		wage		
Assistant	*1,00000*	*wage*	*$ 294,05*	*$ 294,05*
Specialized foreman (cape)	*0,20000*	*wage*	*$ 949,47*	*$ 189,89*
Minor tools	*0,03000*	*(%)labor*	*$ 483,94*	*$ 14,52*
Factor of safety equipment	*0,05000*	*(%)labor*	*$ 483,94*	*$ 24,20*
			addition	*$ 522,66*
EFFICIENCY	160,00000			
COST IN MEXICAN PESOS for labor [m^3]:				**$ 3,27**

Equipment (DESCRIPTION):	AMOUNT	UNIT	RENT	COST IN MEXICAN PESOS
Grader 14-H, de 215 hp, motor CAT 3306	0,02500	hour	$ 788,87	$ 19,72
Compactor CB 634C, de 145 hp, 11.7 ton, wide drum 2.13 m with crowbar roller (sheeps foot roller or vibratory foot roller)	0,02500	hour	$ 454,27	$ 11,36
COST IN MEXICAN PESOS FOR EQUIPMENT [m^3]				**$ 31,08**

TOTAL COSTS		
Direct cost		$ 34,35
Indirect	6,47%	$ 2,22
Field indirect	4,00%	$ 1,37
Subtotal		$ 37,94
Funding	0,25%	$ 0,09
Subtotal		$ 38,03
Utility	10,53%	$ 4,00
Additional Charges	0,50%	$ 0,19
UNITARY COST[m^3]		**$ 42,22**

Table 11: Unitary costs step 1

Depending of the thickness of the RoadCem cement layer construction will the price per m^2 calculated. In table 3.30 are the costs for the preparation per construction summarized:

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Roadtype 1: Highways	$ 13,09	$ 11,82	$ 10,98	$ 10,56	$ 10,56
Roadtype 2: Primary roads	$ 12,67	$ 11,40	$ 10,56	$ 10,13	$ 10,13
Roadtype 3: Secondary roads	$ 13,93	$ 12,67	$ 11,82	$ 11,40	$ 11,40
Roadtype 4: Rural roads	$ 13,09	$ 11,82	$ 10,98	$ 10,56	$ 10,56
Roadtype 5: Access roads	$ 12,25	$ 10,98	$ 10,13	$ 9,71	$ 9,71

Table 12: Summarized construction costs step 1. Given costs are per m2 in Mexican Pesos

Step 2: Leveling and pre-compaction

The second step is leveling of the trace. This have to be done prior to the further steps for a fast processing of the RoadCem and cement. The extended calculations are given in table 3.31:

Materials (DESCRIPTION):	AMOUNT	UNIT	COSTO	COST IN MEXICAN PESOS
Water pipe (not potable)	0,03000	m3	$ 50,00	$ 1,50
COST IN MEXICAN PESOS FOR Materials				**$ 1,50**

Labor (description):	AMOUNT	UNIT	SALARIO	COST IN MEXICAN PESOS
Crew No. 1 (1.00 Assistant)		wage		
Assistant	*1,00000*	*wage*	*$ 294,05*	*$ 294,05*
Specialized foreman (cape)	*0,20000*	*wage*	*$ 949,47*	*$ 189,89*
Minor tools	*0,03000*	*(%)labor*	*$ 483,94*	*$ 14,52*
Factor of safety equipment	*0,05000*	*(%)labor*	*$ 483,94*	*$ 24,20*
			addition	*$ 522,66*
EFFICIENCY	400,00000			
COST IN MEXICAN PESOS for labor:				**$ 1,31**

Equipment (DESCRIPTION):	AMOUNT	UNIT	RENT	COST IN MEXICAN PESOS
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	0,01000	hora	$ 442,42	$ 4,42
COST IN MEXICAN PESOS FOR EQUIPMENT				**$ 4,42**

TOTAL COSTS		
Direct cost		$ 7,23
Indirect	6,47%	$ 0,47
Field indirect	4,00%	$ 0,29
Subtotal		$ 7,98
Funding	0,25%	$ 0,02
Subtotal		$ 8,00
Utility	10,53%	$ 0,84
Additional Charges	0,50%	$ 0,04
UNITARY COST [M2]		**$ 8,89**

Table 13: Unitary costs step 2

Step 3: Applying of the RoadCem and Cement

The step is strongly depending if the dosages RoadCem & cement and the dimensions of the pavement construction. In the following table is an example given for the calculations, based on clay soil.

Materials (DESCRIPTION):	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Construction Sand	0,05040	m3	$ 285,71	$ 14,40
COST IN MEXICAN PESOS FOR Materials				**$ 14,40**

Stabilization basic with roadcem	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Bulk Grey Cement	*200,00000*	*KG*	*$ 1,70*	*$ 340,00*
Water pipe (not potable)	*0,30000*	*m3*	*$ 50,00*	*$ 15,00*
ROADCEM	*2,00000*	*KG*	*$ 396,00*	*$ 792,00*
Crew No 27 (1.00 Oficial + 7 laborer)	*0,00444*	*wage*	*$ 2.948,05*	*$ 13,09*
Grader 14-H, de 215 hp, motor CAT 3306	*0,10000*	*hour*	*$ 788,87*	*$ 78,89*
Soil Compactor with drum vibratory rammers CP563C Caterpillar 145-hp and 11,700 tons of operating weight with 2.13 m wide drum	*0,10000*	*hour*	*$ 442,42*	*$ 44,24*
			addition	*$ 1.283,22*
AMOUNT	1,00000			
COSTS IN MEXICAN PESOS FOR CONSTRUCTION				**$ 1.283,22**

Survey:	**AMOUNT**	**UNIT**	**COSTO**	**COST IN MEXICAN PESOS**
Topography basic with equipment.		m2		
Lime	*0,00500*	*bulto*	*$ 29,00*	*$ 0,14*
Bar / stakes	*0,01500*	*pza.*	*$ 5,00*	*$ 0,08*
electric transit Includes topographer and rodman	*0,01000*	*hora*	*$ 340,89*	*$ 3,41*
			addition	*$ 3,64*
AMOUNT	4,00000			
COST IN MEXICAN PESOS for Auxiliars				**$ 14,56**

TOTAL COSTS		
Direct cost		$ 1.312,18
Indirect	6,47%	$ 84,90
Field indirect	4,00%	$ 52,49
Subtotal		$ 1.449,56
Funding	0,25%	$ 3,62
Subtotal		$ 1.453,19
Utility	10,53%	$ 153,02
Additional Charges	0,50%	$ 7,27
UNITARY COST[M3]		**$ 1.613,47**

Table 14: Example calculation unitary costs step 3

The results are summarized in in the following table.

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand	Old construction
Roadtype 1: Highways	$ 543,33	$ 451,77	$ 383,31	$ 333,77	$ 316,37
Roadtype 2: Primary roads	$ 525,80	$ 435,64	$ 368,57	$ 320,42	$ 303,72
Roadtype 3: Secondary roads	$ 578,38	$ 484,04	$ 412,80	$ 360,47	$ 341,68
Roadtype 4: Rural roads	$ 543,33	$ 451,77	$ 383,31	$ 333,77	$ 316,37
Roadtype 5: Access roads	$ 508,27	$ 419,50	$ 353,83	$ 307,07	$ 291,06

Table 15: Summarized construction costs step 3 in Mexican Pesos per m^2

Step 4: Curing

The Curing of the RoadCem cement layer is essential to reach the required quality of the construction. Especially by high temperatures, wind and low humidity, the RoadCem cement layer could easily dry out. Since the importance is the curing given by an additional step. In table 3.34 are the costs for the curing extended per m^2 stabilization.

Materials (DESCRIPTION):	AMOUNT	UNIT	COSTO	COST IN MEXICAN PESOS
Water pipe (not potable)	0,02500	m3	$ 50,00	$ 1,25
COST IN MEXICAN PESOS FOR Materials				**$ 1,25**

Labor (description):	AMOUNT	UNIT	SALARIO	COST IN MEXICAN PESOS
Crew No. 1 (1.00 Assistant)		wage		
Assistant	*1,00000*	*wage*	*$ 294,05*	*$ 294,05*
Specialized foreman (cape)	*0,20000*	*wage*	*$ 949,47*	*$ 189,89*
Minor tools	*0,03000*	*(%)labor*	*$ 483,94*	*$ 14,52*
Factor of safety equipment	*0,05000*	*(%)labor*	*$ 483,94*	*$ 24,20*
			addition	*$ 522,66*
EFFICIENCY	1.000,00000			
COST IN MEXICAN PESOS for labor:				**$ 0,52**

TOTAL COSTS		
Direct cost		$ 1,77
Indirect	6,47%	$ 0,11
Field indirect	4,00%	$ 0,07
Subtotal		$ 1,96
Funding	0,25%	$ 0,00
Subtotal		$ 1,96
Utility	10,53%	$ 0,21
Additional Charges	0,50%	$ 0,01
	UNITARY COST[m^2]	**$ 2,18**

Table 16: Unitary costs step 4 in Mexican Pesos

Step 5: Wearing course

For the RoadCem constructions are two types of wearing courses used.:

- Chip and Spray
- Asphalt

The available costs for both layers are total costs including supply and process.

	Soil type 1: Organic clays	Soil type 2: Clay	Soil type 3: Sandy clay	Soil type 4: Sand
Roadtype 1: Highways	$ 422,50	$ 422,50	$ 422,50	$ 422,50
Roadtype 2: Primary roads	$ 422,50	$ 422,50	$ 422,50	$ 422,50
Roadtype 3: Secondary roads	$ 121,00	$ 121,00	$ 121,00	$ 121,00
Roadtype 4: Rural roads	$ 121,00	$ 121,00	$ 121,00	$ 121,00
Roadtype 5: Access roads	$ 121,00	$ 121,00	$ 121,00	$ 121,00

Table 17: Summarized construction costs step 5