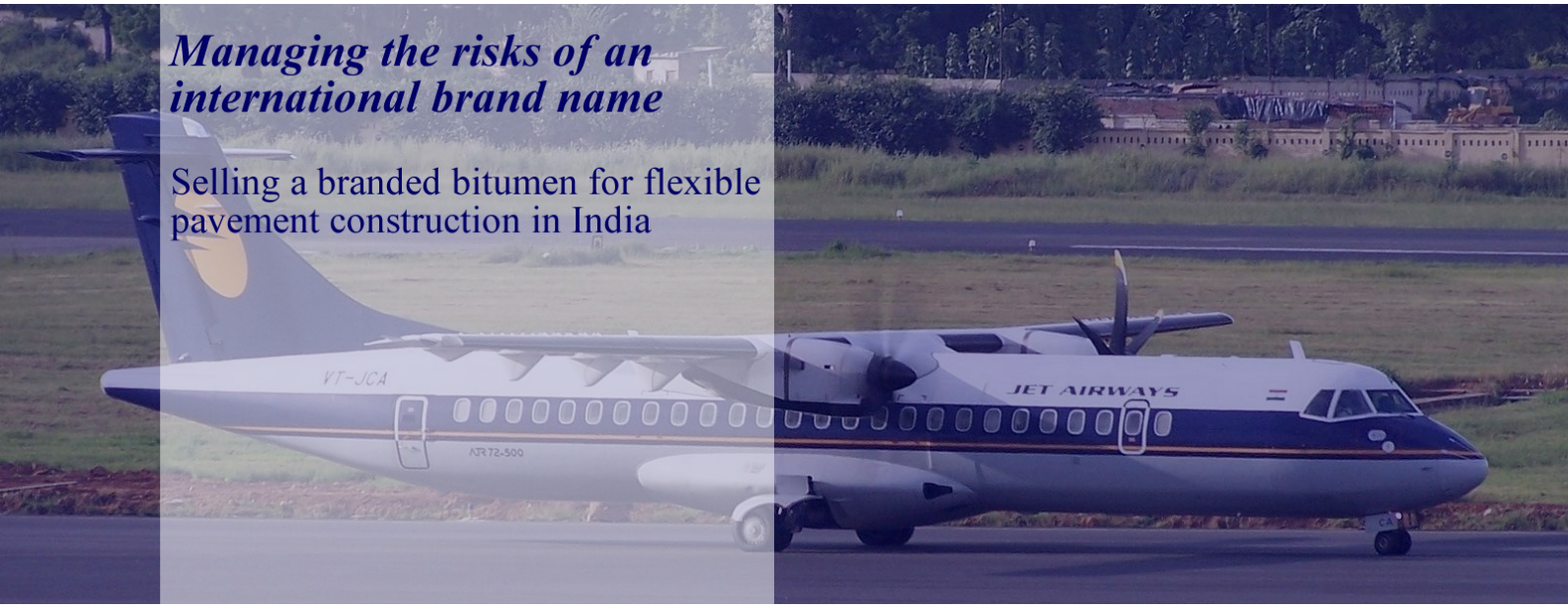

Managing the risks of an international brand name

Selling a branded bitumen for flexible pavement construction in India

Master thesis

University of Twente
The Netherlands

Ooms Avenhorn Holding

Managing the risks of an international brand name

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Master thesis

Master thesis written by
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for graduation at the
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Preface

Besides getting my post graduation in Civil Engineering and Management I was hoping to combine the final phase of my studies with gaining experience in executing an assignment abroad. Thanks to Ooms Avenhorn Holding I got the chance to meet this objective, which has been one of the most impressive experiences in my life. Therefore I would like to thank all the Ooms employees who helped me to formulate and finish this assignment. Special thanks goes to ir. A. Srivastava, Dr. ir. A. H. de Bondt, Dr. K. Ramamurthy and Mr. N. Sarker for their intensive guidance.

I would also like to thank the University of Twente for providing me with the knowledge to succeed in writing this thesis and their sponsorship for sending me abroad. I am also very grateful for the time and effort invested by the university supervisors: Prof. ir. D.G. Mans, Dr. ir. S. J. de Boer and Dr. ir. H. L. ter Heurne.

For gathering information I have visited many people who have given their precious time to speak with me about there work and experiences. Their ready cooperation and help is graciously acknowledged. However none of them is responsible for any errors, omissions or misinterpretations creeping into my thesis, for which I alone take responsibility.

Most grateful I am to my parents for there patience, guidance and sponsorship in all the education which I eagerly undertook in my way to post graduation.

Last but not least I would like to thank all my friends and the rest of my family for there support and especially Brecht for his inspiration and motivation and Marwil who has been most patient for the last three years. I hope my post graduation will mark the beginning of a time in which Marwil and I can spent more time together than ever.

Remko Put

Enschede, February 21st 2006

Summary

The Ooms Avenhorn Groep bv is a holding company with all sorts of construction related subsidiaries. One of these subsidiaries is responsible for production and selling of Sealoflex®, an SBS modified bitumen which is applied in flexible pavement structures. In India, the company has set up a separate company and 3 processing plants because of the great market potential caused by massive development of airport runway and road structures. The product has to prove itself in India and Indians do not rely much on experiences from abroad. From a marketing point of view any failure in a pavement containing Sealoflex® could harm the flawless brand name. There are many aspects in a pavement which can cause failure and as a 3rd part supplier Ooms can only influence the quality of its own product. The actual performance of the product depends for a large part on contractor performance during the execution stage of a pavement construction process, but the design, preparation and operation stage also play a crucial role.

By going through the process of risk management, risks are identified which can lead to premature failure of a flexible pavement in India. A description is given about the quantification of these risks and suggestions are made on how to implement risk management as part of a company policy.

Within the design stage there is a risk that failures are caused by wrongly designed drainage facilities and by the use of wrong traffic parameters. The application of u-turns can cause high stresses on pavements. Maintenance projects encompass overlaying an old pavement. If the old pavement is cracked and no further measures are taken, reflective cracking is evident.

During the preparation stage of a project, land needs to be acquitted and utility cables and pipelines need to be diverted. In India works often start without this work being done. Pavements are constructed piece by piece and many transverse joints are constructed over the entire pavement thickness which eventually can be a source for transverse cracks.

Many causes for failure can be found in the execution stage of a project. This stage is approached by four different angles:

- Manpower - The demand on human resources is very high in India. Skilled labour and engineers are scarce. Skilled labour is scarce because there are not enough affordable training institutes and jobs in the Middle East are financially attractive. Engineers are scarce because Civil Engineering is unpopular compared to software industry.
- Machines – In large construction projects, machines are no cause for any failure. Every type of required equipment is available and some government schemes have made investment in equipment more attractive. The less money is involved, the less quality can be found in the equipment used. In small construction projects still a lot of work is done by hand which negatively influences the pavement quality. Measuring devices are often not calibrated properly.

- Materials – Some Indian specifications regarding materials are mild towards performance requirements which is necessary to make projects economically beneficial. Supervision is essential to make sure that no inferior materials are used.
- Methods – Methods for construction are specified in IRC guidelines. Specifications regarding the use of PMB are limited and some specific information is not available. Time and temperature related specifications are said to be rarely followed in India. Pavement curing times are often too short, planning of asphalt mix supply is weak and temperature control is often lacking. Methods which encompass hand work are generally of less quality than equipment based methods.

Within the operation stage of a project, relevant risks can be identified regarding structure overloading by commercial vehicles, bad drainage maintenance and mechanical or chemical damage by vehicles. Especially overloading is considered to be India's biggest problem in pavement management. Unfortunately the construction sector can only depend on the Government of India (GOI) to deal with this.

Quantification of risks can not be done by considering that all Indian pavement construction projects share the same risks. Quantification is hardly dependent on the environment in which a project is taking place. This thesis approaches the project environment by the following aspects:

- Topography – The physical environment of a project and the classification of a pavement structure, i.e. highway or rural road, influences the construction process and eventually leads to different qualities between projects.
- Culture –In India, there are different cultures which have a different perspective about quality of works.
- Climate – In India, there are different types of climates with extreme colds and extreme heats. Temperature and rain have a tremendous influence on pavements. Not only during its construction, but also afterwards, during its operational stage.
- Economy – Pavement projects are funded in many different ways. In some cases there is insufficient budget for proper construction which reflects in pavement quality.
- Politics – Project stakeholders vary between projects and influence the course of a project. Several types of Indian stakeholders are characterized by a high amount of bureaucracy and/or corruption which reflects in the outcome of the project.
- Legislation – There are different contracts and requirements within Indian projects. Furthermore there are variations in institutes which can be responsible for supervision and not every institute is taking that job seriously and thereby increasing the change that work is not done according the specifications.

Generally it can be said that within projects of national interest the risks of bad quality is minimal. Particularly airport pavement projects and projects within the National Highways Development Plan (NHDP) are considered to be the closest to optimal regarding quality performance. Projects' quality within lower classified roads, like state highways, district roads, etc. vary throughout the country. Project costs is a key indicator, because within a project costing over Rs. 50.000.000 (ca. €

950.000), there is a possibility to set requirements regarding personnel and equipment from which the pavement quality benefits.

The risk management methodology provides four different tools to manage risks, which are: avoid, decrease, transfer and accept. Within this thesis several options are discussed to use these tools to deal with the risk of getting bad publicity on the Sealoflex® brand name, caused by premature failure of pavements built with the product. These are:

- Avoid the risk by not selling the product within high risk factor projects;
- Avoid the risk by selling the product under a different brand name within high risk factor projects;
- Decrease the risk by learning about risks from past projects through an information system;
- Decrease the risk by increasing the influence on the process by involving other Ooms' subsidiaries;
- Decrease the risk by developing a bitumen which is does not require specific handling;
- Decrease the risk by advising to apply a safety factor and thus create thicker bituminous base layers within a pavement;
- Transfer the risk to the company which is responsible for the application of the product by a change in marketing strategy;
- Accept risks.

The emphasis is put on the creation of a learning organisation by the implementation of a worldwide applicable information system. With the help of such a system Ooms' employees should be able to identify and quantify risk more easily on the basis of past experiences. This would require a system which is easy accessible and easy to operate and does not put too much burden on employees for use. Risks can only be managed if they are periodically evaluated, stressing out the necessity of a continuous process which is a part of a company's everyday's operations.

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General introduction

Coca Cola® and Pepsi® are sold almost everywhere in the world. The production of these famous soft drinks is usually done in local production facilities. Inside a factory the production process can be controlled relatively easy because the same process is repeating itself over and over again under the same conditions. Nevertheless in 2003 Coca Cola® and Pepsi® had to give account for the findings of pesticides and other toxics in their cola which was manufactured in India. Although the companies denied the claim, the entire world demanded an explanation.

Sealoflex® is a modified bitumen which is produced and sold in several countries throughout the world by subsidiaries of the Ooms Avenhorn Groep bv. The production is done in local factories where the process can be controlled relatively easy. After leaving the factory, Sealoflex® is used as a building material in the construction of flexible pavements. Within these pavements the product has to perform. The construction of the pavement however, is done by another party and it is done outside where the ever changing environment has great influence on the production process.

One of the countries where Sealoflex® is produced and sold, is India. This country is developing in a rapid pace and aiming to become a developed country by 2020. This thesis describes a research in which the Indian construction process of flexible pavements is investigated. The objective is to find out whether failures in this process can cause the Sealoflex® product not to perform according to its expectations.

This thesis consists of six parts. Part I describes background and the structure of the research. Part II describes the Indian flexible pavement construction environment which has a great influence on the construction itself. Part III describes some possibilities of failure within the Indian construction process. Part IV describes how these possibilities of failure can be quantified. Part V describes how a 3rd party supplier can influence the construction process to improve the handling of its product. Finally part VI describes the conclusions which can be drawn from the previous parts and provides recommendations for future research.

Part I

Research plan

Within part I of this thesis a description is given about the history and background of the Ooms Avenhorn Groep and its business in India. Based upon this information, the problem is defined. Subsequently a description is given about the set-up of this research and how it will answer the questions which rose out of the problem definition.

1 Background and problem definition

1.1 Ooms Avenhorn Groep bv

Ooms Avenhorn Groep bv is a Dutch holding company whose everyday operations, both in the Netherlands and internationally, includes the execution of earthmoving, hydraulic and infrastructure projects, the construction of houses and office complexes and the development and production of modified bituminous binders. The company has two major subsidiaries. The first is a holding company, divided into several divisions which are engaged in project execution and product selling. The other is Unihorn, which is engaged in designing, advising, consulting and supervising activities in the field of infrastructural projects. The divisions and the engineering consultancy all operate as independent units, but also undertake projects jointly. The Ooms Avenhorn Groep is able to see projects through from beginning to end, from site preparation, installation of underground infrastructure and the development, construction and sales of houses to the provision of above ground infrastructure such as asphalt concrete pavements and landscaping.

Ooms' division Trade & Industry sells products like GlasGrid® asphalt reinforcement and Sealoflex® polymer modified bitumen (PMB). Except for India, international sales are operated by the Dutch division or by local agents. Indian infrastructure development is huge and due to the hot climate and heavy axle loading, Ooms' products have a great potential. For this reason Ooms has set up a separate Indian company in 1999 to serve the Indian infrastructure market.

Gurgaon based Ooms Avenhorn Holding India Pvt. Ltd. sells and advices clients in pavement structures and pavement construction related products. Production and sales of Sealoflex® polymer modified bitumen is executed by a subsidiary called Ooms Polymer Modified Bitumen Pvt. Ltd. which has three Sealoflex® production plants near Chennai, Mumbai and New Delhi.

In 2001 Unihorn bv started a joint venture in India with infrastructure consultant Engineers and Management Associates (EMA) called EMA Unihorn India Pvt. Ltd. In 2002 the joint venture ended and EMA Unihorn India Pvt. Ltd. is since then fully owned by Unihorn bv.

Figure 1 represents Ooms' organization chart for the companies and divisions in the Netherlands and in India.

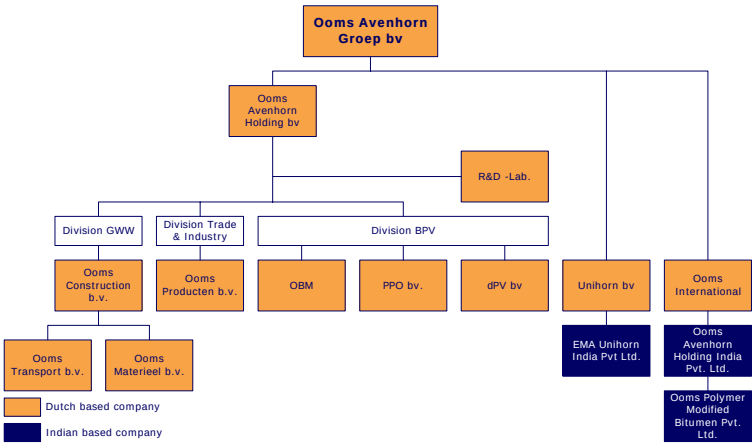

Figure 1: Organization chart of the Ooms Avenhorn Holding Groep

1.2 Sealoflex®

Generally there are two type of pavements: Rigid pavements and flexible pavements. The latter contains bitumen which applications in roads dates back to several centuries B.C. Bitumen which is also known as asphalt was obtained out of natural lakes. Nowadays most of the bitumen is produced in oil refineries by fractional distillation of crude oil. The quality of bitumen is largely dependent on the quality of the source of the crude oil and the refinery and has some negative properties for specific applications. Therefore bitumen are modified for selected projects with several different types of modification.

Sealoflex® is a bitumen which is modified with an elastomer called Styrene Butadiene Styrene (SBS). This type of modification is quite common with other manufacturers, but Sealoflex® distinguishes itself by the use of Gellation Technology which gives the product superior properties regarding to other PMBs in respect to handling and aging (Srivastava; 2001).

Sealoflex® is costlier than conventional bitumen, but maintenance costs are reduced because the product increases the life span of a pavement. The total life-cycle costs of a pavement containing Sealoflex® are therefore less than the life-cycle costs of pavements containing conventional bitumen.

Figure 2:
Worldwide situated Sealoflex® manufacturing plants as per 7-10-'05

The first Sealoflex® project was carried out in the Dutch city of Alkmaar in 1982. Since then millions of tons of Sealoflex® asphalt concrete is worldwide applied on airports, roads and industrial areas. Nowadays there are almost 40 Sealoflex® manufacturing plants in operation in 16 different countries and more are likely to be built in the near future (figure 2). Many plants are placed permanently, some are only built for the duration of a project.

1.3 Problem definition

India is a relatively new market for Ooms. Indians do not much rely on worldwide experiences so the performance of Sealoflex® has yet to be proved. Ooms is creating a distinct profile for itself by using a brand name. This type of marketing is not very common in construction, but is a very welcome innovation in creating an improved construction sector (Halman; 2004). The downside of brand names is that a good reputation, which is built up in several years, can be destroyed by one bad incident or even a bad reference by an influential individual. Examples of brand destruction are Exota® and Buckler® in the Netherlands, Firestone® in the United States and Coca Cola® in India, when pesticides and insecticides where discovered in the soft drink. The latter case involves the violation of human rights which is not the case within Sealoflex® production, but the case represents a scenario in which an incident can lead to worldwide loss of product sales (figure 3).

The average life expectancy of Indian roads is 3 years. Ooms guarantees a life span of 8 years when Sealoflex® is applied. Although bitumen has a big influence on pavement quality, there are many other aspects which can cause pavement failure. If a pavement fails by improper use of Sealoflex® or improper construction of any other pavement element, a road owner will first remember the brand name which was related to long term service life of its road. Even if the failure can not be traced back to the PMB, the brand name will be brought into disrepute, especially by persons who are within high level management of an organisation and not aware of the minor facts. People are inclined to remember bad news about a brand.

University of Michigan Bans Coke Products

The college's action is prompted by concerns about the company's practices overseas.

From Reuters

Coca-Cola Co. on Friday said it was banned from another college campus this month when the University of Michigan halted purchases of the company's products because of concerns about the soft drink maker's labor practices in Colombia and environmental actions in India.

The move by the school, which has more than 40,000 students, follows a similar ban this month by New York University, which has more than 50,000 students. The two are among Coke's largest university accounts.

Administrators at the University of Michigan could not be reached for comment.

Environmental groups have accused the world's largest soft drink company and its bottlers of draining water tables in India and worsening its drought conditions.

A group of labor activists also has been waging a campaign against Coca-Cola and its bottling partners for several years, accusing them of hiring right-wing death squads to intimidate union activists at Colombian bottling plants.

Atlanta-based Coca-Cola has denied the allegations and said it believed that its bottlers were not involved in any of the atrocities in Colombia.

Coke also said there was no evidence linking the company or its bottlers to the groundwater problems in India.

"It is a very unfortunate. The actual volume in terms of sales is small but it is the larger issue of our reputation," a Coke spokeswoman said. "These allegations are false but we do share the concerns with issues."

In May, more than a dozen universities talked with Coke and later formed a commission to investigate the company's labor practices in Colombia with Coke's approval.

Coco-Cola shares fell 29 cents to $40.31 on Friday.

Figure 3: Los Angeles Times (e-paper): December 31st, 2005

From a marketing point of view, premature pavement failure is a huge risk for the Ooms company. Especially in a growth market as India where Ooms' product still has to prove itself. There is even an Indian scepticism towards modified bitumen to overcome, because of bad experiences with rubber modified bitumen (RMB), which is very much different from PMB. Ooms has entered the Indian market with a long term perspective. The company has built plants which can deliver Sealoflex® all over the country. Ooms can assure the quality of its own product, but initially has no grip on the construction process. The success of its product is largely depending on contractors who are responsible for applying the product.

Problem definition:

Ooms' success with selling Sealoflex® PMB in India is largely dependent on the performance of the companies which are responsible for construction of the pavement which encompasses the product. Ooms can only directly influence the quality of its own product but from a marketing point of view, all kinds of premature pavement failure cause negative publicity for the Sealoflex® brand, especially in a growing market as India where road owners are not yet convinced of the need for PMB.

This problem is not an isolated problem which only occurs in this situation. Many of Ooms' products are processed by other companies, like GlasGrid® asphalt reinforcement or Road Energy Systems®.

2 Research description

2.1 Research objective

The research is divided into two phases:

- A problem diagnosis phase in which risks of premature failure within Indian pavement constructions are identified and quantified.
- A solution design phase in which risk management tools are identified and recommendations are given on how to implement these tools.

Research objective:
The objective of this research is to identify and quantify possible risks of premature failure within Indian flexible pavements which are caused during the construction process, to find risk management tools to control these risks and to create recommendations on how to implement these tools.

In India, the largest developments regarding bituminous pavements are seen in roads and airfields. Therefore this thesis is restricted to these pavements only.

2.2 Research questions

To achieve the research objective, research questions are used to act as a guideline through the entire research process. The main objective is achieved when all of the research questions are answered. The questions which are applicable for this research are generated out of three of the four steps encompassing risk management. Executing risk management means that, in every stage of the project, risks and uncertainties are analysed by means of identification and impact estimation. The next step is to control the risks by periodically evaluating the events and, when necessary, responding to changes. The complete cycle starts again at the beginning of the next stage of the construction project. Figure 4 represents these four steps of the cycle which correspond to the next questions:

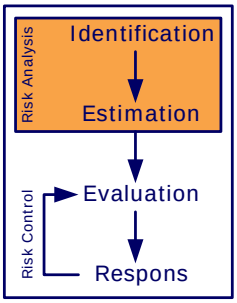

Figure 4; Cycle in risk management (Altered original from v.d. Does de Bye/ v. Kinderen/ Stam; 1999)

1. What is the risk that an Indian flexible pavement structure will fail prematurely by failures within the construction process?
    a. What is the risk that the level of skills is too low for constructing a high quality flexible pavement?
    b. What is the risk that there is no suitable equipment available for constructing a high quality flexible pavement?
    c. What is the risk that inadequate construction materials are used in India?
    d. What is the risk that contractors do not follow production instructions or that instructions are incorrect?

2. What is the chance that this risk will occur and what are the consequences?
    a. Which quality control measures are used?
    b. What experience do experts have with the identified risks?
    c. What effect does the environment have on the product quality?
3. What risk control tools can be used to minimize the risk?
    a. What risk control tools are available?
    b. Which of the available risk control tools can be applied by a 3rd party supplier?
    c. How can risk management be implemented in the process of upcoming projects?

2.3 Research approach

To find an answer to the research questions, secondary data was collected out of literature to identify possible causes of pavement failure. This has resulted in a failure tree which reflects the events that could lead to the problem. Figure 5 represents this failure tree.

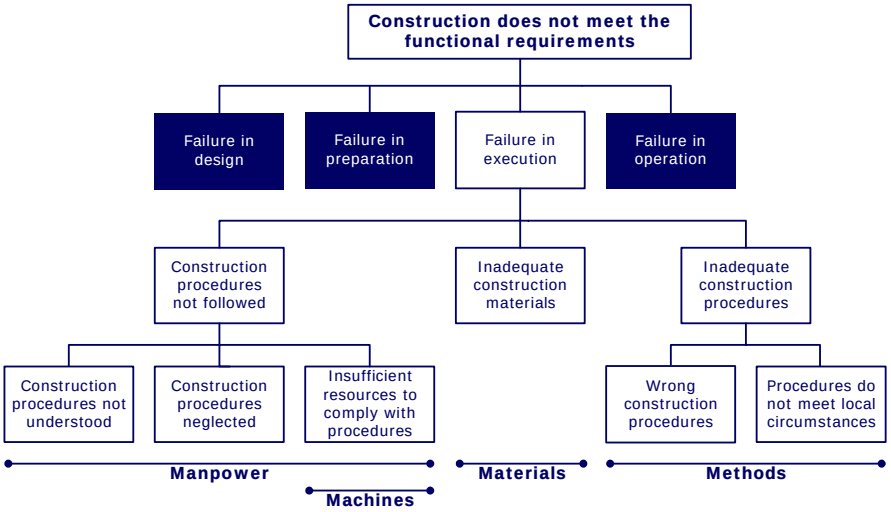

Figure 5: Failure tree for analysing the possibilities of failure in Indian road construction processes

These possible causes were assessed in a case study by means of interactions and project visits for observation. A total of 22 interactions, covering road agencies, contractors, constructors, consultants, concessionaires, road engineers, academic institutions' professors and research & development personnel, have contributed to the gathering of information. A list of visited persons and an example of the introduction letters of Ooms and the University are given in appendix I.

Unfortunately observations were limited because of the monsoon period. Nevertheless a total of 6 short visits to construction sites could give insight to the situation and enlighten some topics which needed to be cleared after the interactions.

Besides the official interactions and project visits, students of the Indian Institute of Technology (IIT) and employees of many other organisations have helped with creating a picture of Indian Road construction in informal conversations about this topic.

The research is mainly focused on failures caused within the execution stage, but there are some elements within the design, preparation and operation stage which are important to consider when

guarantying a pavement life span in India (figure 6). Van der Does de Bye, van Kinderen and Stam (1999) advise to analyse project execution risks in an early stage of a project.

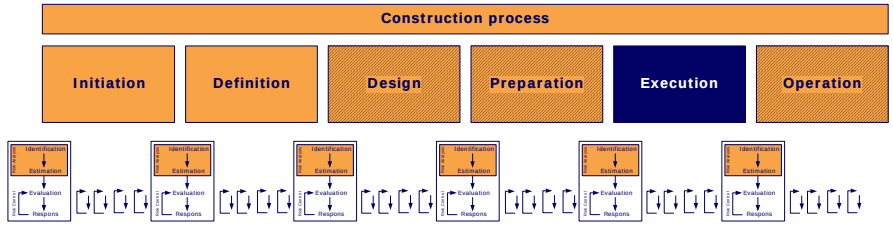

Figure 6; This thesis mainly focuses on potential risks in the project execution phase.

In risk management there are qualitative techniques, quantitative techniques and semi quantitative techniques (Vermande&Spalburg;1998). This research is restricted to the latter type of technique where potential risks and sources of risks are detected in a risk analysis. Quality is the subject of analysis and according to the Japanese quality guru Kaoru Ishikawa (1995), this can be influenced by four different aspects which were also recognized in the failure tree of figure 4:

- Manpower
- Machines
- Materials
- Methods

These aspects are in their turn influenced by the environment in which the project is taking place (figure 7). The environment in this thesis will be analysed on a country level, thus India being the subject of analysis. Six environmental aspects have been recognized which influence the quality aspects of a project:

- Topography
- Culture
- Climate
- Economy
- Politics
- Legislation

Figure 7;Project execution within a certain environment

2.4 Research structure

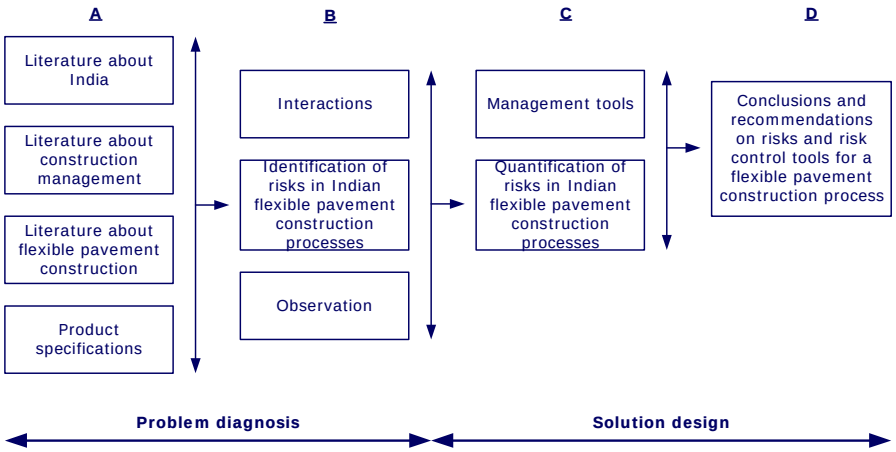

Figure 8: The structure of the research described in this paper

Figure 8 represents the model of the research approach mentioned in chapter 2.3
The model converted into words:

(A) A study of literature about India, construction management and flexible pavement construction is confronted with product specifications.

(B) The result of the literature study is an identification of risks that might occur during the construction process. These risks are assessed in practise by observation and interactions with experts in the field of Indian road construction.

(C) The result of the case study is a quantification of the risks to create insight in the chances and the consequences of occurrence. The quantified risks will be set aside available risk control measures.

(D) This results in conclusions on quality related risks in an Indian pavement construction process and recommendations on how to minimize the occurrence and the effects of possible risks.

Part II

Indian flexible pavement structures

Within part II of this thesis a description is given about Indian flexible pavement structures and its most frequently occurring failures. Furthermore the Indian project environment is described to generate a picture about the context in which Indian construction processes are taking place.

3 Standard pavement construction

There are four different types of pavement structures: Composite, rigid, semi-rigid and flexible pavement structures. A flexible pavement is partly built out of asphalt concrete and is the most widely applied pavement in Indian road, runway and taxiway construction. Other airport elements, like aprons and turning pads are mostly built out of rigid pavements. Indian Specifications and Codes of Practice prescribe that a flexible pavement generally consist out of the following layers:

- Bituminous wearing course;
- Bituminous base;
- Granular base;
- Granular sub base;
- Natural subgrade.

The construction process of the separate layers is the same in India as in the rest of the world. This process is visualised by a diagram generated with the Structured Analysis and Design Technique (SADT) in appendix II. The several steps within the process have been given an ID which is used for further analysis.

The wearing course is the topmost layer of the pavement whose purpose is to provide a hard, smooth but skid-resistant, dust-proof and impervious layer. Immediately below comes the bituminous base course or binder course which is designed to withstand the high stresses imposed by the wheel loads and to distribute them to the lower layers. The base courses can be built out of bituminous materials or of granular unbound materials. The bottom-most layers of the pavement crust are known as the sub–base courses. These may be constructed in a variety of materials, such as gravel, stone aggregates or stabilised soil. The pavement rests on the soil, which is known as the natural subgrade (figure 9). The thickness of the pavement components depends for a large part on the amount of traffic the road has to bear and on the condition of the subgrade.

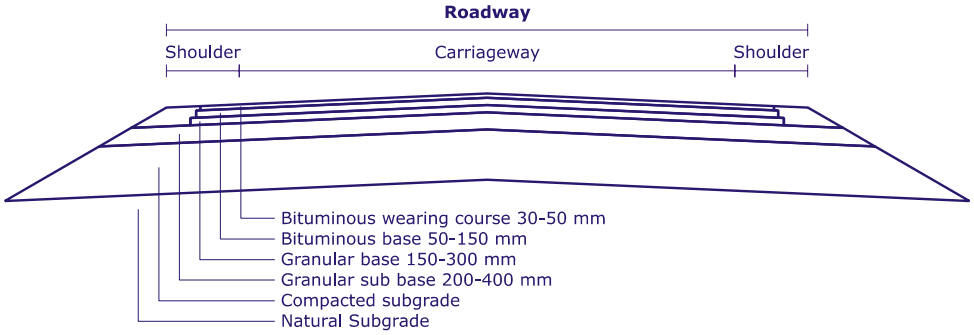

Figure 9: Typical flexible pavement components (MORTH: 2001)

A bituminous course is a skeleton of aggregates and sand which is enclosed by a mastic. This mastic consists of bitumen and filler dust. These ingredients are mixed at high temperatures in a mixing plant. The hot asphalt mix is transported to the site and is mostly paved by a machine. The mix is mechanically compacted until the required level of compaction is reached.

4 Functional requirements of a flexible pavement structure

To minimize risks in practice and simultaneously create a meaningful application of an asphalt pavement, functional requirements are applied in a larger extent. To specify functional requirements the so called “pyramid of requirements” is used where the requirements are split into five abstraction levels, all of which have a different stakeholder:

- Level 1 User demands (pilots, drivers, passengers);
- Level 2 Performance requirements (operational and technical managers);
- Level 3 Requirements concerning the constructional behaviour (designers);
- Level 4 Requirements concerning the behaviour of the used materials (contractor);
- Level 5 Requirements concerning the nature of the used materials (supplier).

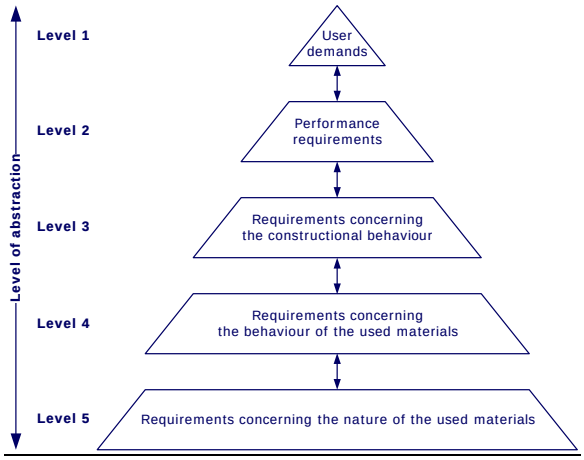

Figure 10: Technical pyramid of requirements (Molenaar; 2004)

The requirements of the pyramid are being transferred from a high level towards lower levels of abstraction. For example: A user demands a safe and comfort ride. These demands are translated into performance requirements like a level and rough surface which reduces noise. These requirements subsequently create requirements for the entire pavement construction, as well as to the raw materials that are used. Figure 10 visualizes the different levels of abstraction.

Level 1 Use	Level2 Manage	Level 3 Design	Level 4 Construct	Level 5 Supply
Safety	Roughness Levelness Visibleness Aquaplaning	Micro/macro texture Resistance to deformation Anti-skid surface (airfield)	Asphalt composition	Construction material properties
Comfort	Longitudinal levelness Surface unevenness Deformation Footprints	Ground mechanical aspects Material selection Construction structure	Asphalt composition	
Durability	Chemical resistance Cohesion Ravelling	Surface characteristics Mixture selection	Asphalt composition Ravelling resistance Processableness	Construction material properties
Availability	Bearing ability Maintenance sensitivity Construction pace Maintenance	Bearing capability Construction structure Material selection Long-term behaviour	Cracking resistance Wearing resistance Ravelling resistance	Construction material properties
Environmental Friendly	Sound level Recycling	Material selection Macro texture		Construction material properties

Table 1: Relation between functional requirements and level of abstraction (Molenaar; 2004)

Table 1 shows the relationship between the different levels of functional requirements (Molenaar; 2004). Especially for Indian road users, the level 1 requirements will differ from European road users. Although in India, people are bothered by road failures, there expectations are much lower. Expectations of road owners are quite the same everywhere, therefore this thesis focuses on not achieving level 2 requirements by failures caused within level 4 and 5 activities.

5 Structural failure in Indian pavement constructions

There are many different types of asphalt pavement failure, but not every failure is common in India. The Central Road Research Institute (CRRI) claims that the failures described in table 2 are most common in India, reducing the average life span of an Indian flexible pavement to only 3 years. Causes for these failures can be found throughout the entire construction process within granular base layers as well as in the bituminous layers. The application of Sealoflex® can reduce or even prevent some of the failures, but not all of them.

Failure	Description
Cracking	
Longitudinal	Cracking parallel to the road direction
Transverse	Cracking perpendicular to the road direction
Mesh	Cracking which is also known as alligator or map cracking which are intersecting cracks dividing the pavement surface into isolated elements of different sizes down to the small elements
Joint reflective	Cracking that reflect in block-shape out of sub base courses
Bleeding	When a surface is bleeding, bitumen appears above the pavement surface
Corrugation and shoving of the mix	Corrugation and shoving if the mix expresses itself in permanent deformation where weak materials are forced up through the pavement courses and progressive disintegration of the mix
Stripping	Stripping is characterized by separation of bitumen adhering to the aggregate particles surface. Eventually this leads to loss of strength and/or ravelling
Ravelling	Ravelling is the type of failure where the aggregates are not properly surrounded by mastic. The stone particles on the surface are picked out by traffic which eventually leads to potholes.
Potholes	Potholes are bowl-shaped holes of varying sizes which can extend to several layers in a pavement. Usually the thin wearing course is disintegrated by cracks, ravelling or mechanical damage. Water penetrates the underlying layers and the pavement looses its strength locally. Traffic picks up aggregates and potholes are formed.
Depressing	Depressions are localised low areas of limited size dipping about 25 mm or more below the desired profile, where water will normally collect.

Table 2; Most common Indian flexible pavement failures

6 Construction environment

The construction of a pavement structure is to a large extent done outside where the environment has a huge influence on the construction process. In this thesis the environment is approached by 6 different characteristics: Topography, culture, politics, economy, legislation and climate. Within this section the key elements of the Indian construction environment are highlighted. A more extensive description is given in appendix III.

India's environment is characterized by the sheer size of the country where different landscapes can be found like deserts, rainforest and rocky mountainous areas. To cope with the demands of an immensely growing transportation sector, massive infrastructure projects have been undertaken which put a heavy burden on the availability of resources. The main developments are in airports and road infrastructure in which the National Highway Development Plan (NHDP) is the most impressive project encompassing the construction and reconstruction of 4 to 6 lane roads with a total length of 24.279 km to provide an efficient connection between the most economic important cities of Mumbai, New Delhi, Kolkata and Chennai (figure 11). The entire Indian road network exceeds 3.3 million km and is managed by several different public authorities (table 3).

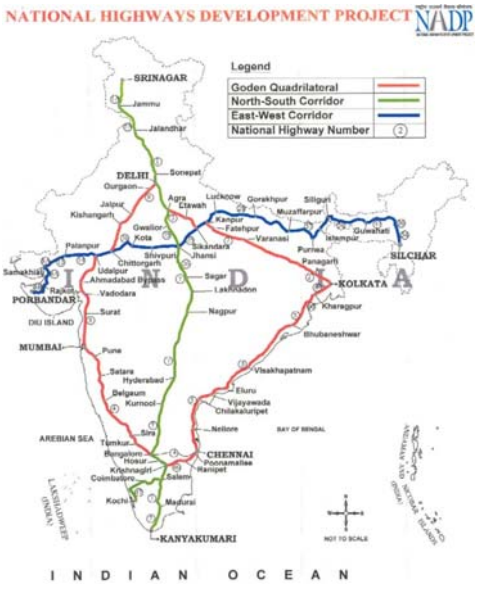

Figure 11; NHDP map (Website NHAI; 2005)

Classification	Total length	Managed by
National Highways	65.569 km	MORTH/NHA
State Highways	131.899 km	State government
Major District Roads	467.763 km	State government
Village and Other Roads	2.650.000 km	Municipal councils/MRD/Other

Table 3; Indian road network (Website NHA; 2005)

National and state road construction projects are often tendered in large packages to make the project economical beneficial for contractors which have to mobilize their equipment. Small projects are usually executed by local contractors.

Another environmental characteristic is the diffuse culture throughout the country which is considered to be originated from a village-orientated culture. The Hindu religion and the caste system are qualities which are hard to understand for outsiders. English and Hindi are the official languages, but over 14 other languages like Tamil or Bengali are recognized by the government. Indians tend to operate as "islands" and often perceive their own particular community as the centre of the world. They may often be parochial, which leads them to be critical and negative rather than supportive of one another. In construction projects there used to be not much affection with the constructed object, no sense of pride and duty in work, which is reflected in the quality of works. The fact that the work had been carried out was sufficient for people to state that they had

fulfilled their task. Developments have resulted in a free-market in which competitors have increased their performance and quality is becoming a major issue.

Indians tend to ignore problems and will not always inform others about upcoming difficulties, probably hoping it will fade away. They tend to create a view which is more optimistic than realistic, which can lead to disappointments or in problem development beyond low-cost intervention. Accountability is weak and procrastination is evident, especially in the public sector (Dunung; 1999), which is the biggest client in pavement construction.

The governmental structure is inherited from the British who ruled India for over a century. The form of government is parliamentary and every state and union territory has its own government with restricted powers. The government consist of three separate branches (trias politica): The executive, the legislative and the judiciary. Unfortunately politics are characterized by corruption and endless bureaucracy, which both have been an item on the governments' agenda for a long time. The Central Vigilance Commission of the GOI has recognized that corruption has led to the paying of bribes to supervisors if quality was poor (Central Vigilance Commission, 2002).

India's economy is growing rapidly, but only a part of its inhabitants benefit from it. There is a huge gap between the poor and the wealthy. The country is aiming to be a developed country by 2020 and the Government of India (GOI) has recognized that infrastructure development is a key element in achieving this goal. Large investments are made, partially with the help of foreign aid and borrowings, partly with private sector participation. Many infrastructure projects are tendered on Built Operate and Transfer (BOT)-basis in which a private organisation is responsible for the constructed object for a period of 30 years. Funds are generated by tolls in the case of roads. It is expected that BOT operators are more concerned about quality than public road owners. Bad quality pavements require maintenance which affects the operators' profit.

India's legislation is strict, but control is weak due to a lack of resources. This concerns the national legislation as well as the legislation within construction projects. Weak supervision encourages contractors to save money at the expense of quality. One example is ignoring rains which badly influences construction. India climate is characterized by a monsoon season which moves over the country. Temperatures differ throughout the country, but within several places, temperatures above 45°C can be experienced, which makes it difficult for a pavement to cool down after paving. Mountainous areas are characterized by extreme colds in winter. If temperatures are low, it is difficult to pave asphalt mix, because it cools down too soon.

Temperature deviations and heavy rainfall not only influences the pavement quality during construction, but also accelerates deterioration after a road is finished. PMB offers bigger resistance against climatic influences, but only when it is applied and handled properly, which is not always the case in India as described in section 9.3.

Interim conclusions part II

The majority of Indian pavements are flexible pavements which are built out of several granular and bituminous layers. Within this thesis the functional requirements of flexible pavements are approached on a level which concerns the pavement owners, because the road user requirements are different in Europe and India. Indian road users generally have lower expectations regarding pavement quality. Indian road owners encounter many different types of failure which can be traced back to the base, sub base and wearing courses of a pavement. Some failures within bituminous courses can be reduced by the application of PMB, but not all of them. Therefore the construction process of these courses are discussed in part III to identify risks of failure.

India's construction environment is characterized by the huge developments in the transport sector. Massive infrastructure projects put a heavy burden on available resources, especially human resources. The sheer size of the country not only brings along huge differences in geological and climatological aspects, but also differences in cultures. The economic growth of the country is unequal divided between states and also within them. All these differences makes it difficult to asses the country as a whole. Projects are funded through market borrowings, foreign aid and private sector participation. The pressure to perform is higher within the latter two types of funding.

Despite hard efforts to get rid of bureaucracy, corruption and low accountability, these characteristics are still seen within the public sector. Along with the country's development the public awareness is increasing and this will improve public pressure for efficient governmental money spending. This is one of the reasons why better quality roads are seen within more developed areas of the country.

Part III

Risk identification

Part III of this thesis answers the 1st research question by identifying quality risks within the construction process of a flexible pavement structure. Risk identification is the 1st step within risk analysis, which should be executed at the start of every stage within a construction process. The goal of the risk analysis is to create a systematic overview of the foreseen risks. It is not possible to include all risks in the risk analysis. The analysis is a knowledge generating process in which the risks are identified by gathering information out of experiences and analysing previous executed projects (Van Dam; 2004).

7 Design

Who is responsible for the design, depends on the kind of project. For example the NHAI hires consultancy agencies which create a Detailed Project Report (DPR) for a certain stretch of road. Besides design, this type of report contains a feasibility study, ecological studies, material studies, etc. Within other projects, public authorities can be responsible for the design themselves. The design method for flexible pavements is recorded in standards of the Indian Roads Congress (IRC) and is related to:

- California Bearing Ratio (CBR) of the subgrade
- Traffic in million standard axles
- Width of the road
- Types of vehicles operating on the road

There are vast road construction projects in India. Some contracts contain over 200km of road which have to be constructed. Interviewees stated that in several cases the design was based on only a few measurements of the subgrades' bearing capacity. An average design was applied over the entire stretch. Places where the bearing capacity was too low, a contractor needed to prepare the subgrade to meet the requirements. If this was unexpected because it was not stated in the designs, a contractor would try anything to minimize the work, depending on the type of contract. Pavement failures like cracking and shoving or corrugation of the mix will probably occur on the stretches where the subgrade does not comply with the required bearing capacity. Applying polymer modified bitumen will not deal with this type of base failures.

Structure overloading is very common in India. Highway structures which are used by commercial vehicles are designed to bear an axle load of 8.2 tons. According to the law, axle loads up to 10.2 tons are permitted. Theoretically the construction is therefore assured to be overloaded by 2 tons. Although the axle load exceeds the limit with approximately 25%, the damaging effect is many times bigger at approximately 140% because of the Fourth Power Law, which is used for structural design purposes: "The damaging effect of an axle load is the fourth power of the relative axle load compared to the standard load" (EAPA; 1995).

$$\text{Damaging effect}_{\text{structural design}} = (\text{A-Load}_{\text{relative}}/\text{A-Load}_{\text{standard}})^4$$

In practise the difference between designed axle load bearing capacity and used axle loads is much bigger, which is described in section 10.

Another reason for overloading is the fact that designers sometimes underestimate the immense growth of India's economy and rigorous changes of policy. During the design process, future industries are not always taken into account. A new industry could mean a dramatic change in traffic mix. Road functions can also change during time. If a road has been built for connecting two small cities, five years later the same road could be a part of a main corridor between two metropolises.

Combined with high temperatures, overloading causes the mix to compact more than it should. With no voids left to fill with material, the bitumen will emerge at the surface. This phenomenon is known as bleeding. If overloading causes the sub base courses to collapse, permanent deformation occurs in the form of rutting and corrugation or shoving of the mix. Applying polymer modified bitumen can increase the bearing capacity of a road, but only to a certain extent.

Corrugation or shoving of mix can also be caused by the ingress of water, just as depressing and the development of potholes. Ingress of water can be prevented by designing efficient drainage facilities. Unfortunately this has not been a priority in Indian road designs. Many roads have been designed mainly focussing on the carriageway and building as many metres as possible for the lowest price. Especially urban roads are not always designed to deal with heavy rains. Road maintenance still does not always encompass the construction of drainage facility, but within new pavement constructions drainage is generally taken into account.

Many roads in India have multiple lanes which are divided with a barrier in the middle of the road. At several distances of each other there are interruptions in this barrier to allow traffic to make a u-turn. The pavement nearby the u-turn is suffering from tremendous shear stress causes by traffic which has to brake or avoid traffic which is waiting to make the u-turn. Eventually this can lead to depressing and ravelling.

Indian designs for pavement maintenance often encompass overlaying a pavement structure without removing the old wearing course by cold milling. Cases have been reported where bridges collapsed under the heavy weight of several layers of asphalt which where applied over the years and exceeded one meter in thickness. Manhole-covers, situated several centimetres below the surface, can also be found. If an old wearing course is cracked, these cracks will eventually reflect through the new wearing course. Reflection cracks can be reduced by using asphalt reinforcement, but in India this is not often applied.

Risk identified within the design stage of a flexible pavement construction process are summarized in table 4.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
DES			01	Inadequate pavement thickness	Bearing capacity too low
DES			02	Inadequate traffic parameters	Overloading of the structure
DES			03	Inadequate drainage facilities	Ingress of water in base and sub base layers
DES			04	U-turn	Stress on pavements by braking traffic
DES			05	Overlaying without milling	Cracks reflect through the surface

Table 4; Risks identified within the design stage of flexible pavement construction process.

8 Preparation

Before project execution starts, some preparations should be made by different stakeholders within a project. One of these preparations encompasses the acquisition of land which has proven to be a hard task in India, just as it is in other countries. As India is a democracy, people have the right to vote against certain decisions and if these decisions involve giving up their land, they certainly will. This problem does not only occur with civilians, but also with public organisations. The AAI did not want to give up a piece of land adjoining the New Delhi's Indira Ghandi Airport to the NHAI. The conflict caused a 2 year delay in the NH8 project between Delhi and Gurgaon.

In many cases, land acquisition is extra delayed because of land ownership being badly recorded or lost somewhere in a bureaucratic process. Land owners were nowhere to be found, or there where several people claiming to be the owner. The same thing happens with utility cables and pipelines where an unknown owner is responsible for repositioning them.

Unfortunately these problems do not only affect the planning, but can also affect the pavement quality. After roads are tendered, contractors are keen to get started to meet the deadlines or to generate income. It is also common to retrieve bonuses if projects are finished earlier as planned, or to retrieve sanctions if they finish too late. The latter is of course not applicable if the delay is caused by an external factor. If work starts and not all land is acquired, the stretch will be constructed piece by piece, creating several transverse joints in every course. Pavements can contain over 7 layers, so joints will be created over a length of 5 meters or more (figure 12). A joint is a weak place in a construction and can eventually lead to transverse cracking, therefore the amount of joints should be minimized. These problems occurred especially in the past GQ projects. Within a reconstruction project of 43 kilometres on NH5 near Chennai, the contractor had to create approximately 30 transverse joints over the entire pavement construction, sometimes only finishing stretches less then 500 meters of length.

Figure 12; Joints within several layers

In future NHDP projects the AAI plans to only tender projects of which all the land is acquired, but within other projects the risk remains. It would take a long time before the ownership of utility cables and pipelines is organised.

Risk identified within the preparation stage of a flexible pavement construction process are summarized in table 5.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
PRE			01	Land acquisition incomplete before project start	Lateral joints
PRE			02	Unknown pipelines and utility cables	Lateral joints

Table 5; Risks identified within the design stage of a flexible pavement construction process.

9 Execution

Many types of common Indian pavement failures can be traced back to the execution stage of a construction process. In the next sections this phase is approached by the four M's related to product quality: Manpower, Machines, Materials and Methods.

9.1 Manpower

Although road construction is largely dependent on equipment based methods, manpower still plays a crucial role within the process. Engineers are necessary for design, planning, supervision, etc. Skilled labour is necessary for operating machinery and much work is done by unskilled labour. The Indian pavement construction sector is characterized by huge demands in human resources because of the huge amount and sheer size of road and airfield construction projects. A.K. Mookerjee and M.K. Saxena (2002) calculated that the infrastructure sector would require approximately 27.000 civil engineers. Unfortunately the civil engineering branch is quite unpopular with aspirant students. Universities and colleges appoint students after they have taken an admission test. The highest scorer is the first one to choose its study. Indian Institute of Technology (IIT) statistics revealed that the past few years top rankers chose Information Technology (IT) until all seats were filled (IIT; 2005). Civil engineers are generally mid-range scorers in the test and even after getting there degree, the software sector seems to lure every engineer, irrespective of there background (figure 13). The software sector is popular because of its very well paid 9-5 jobs in air conditioned offices while civil engineers have to work long hours in tremendous heats with low wages which also demotivates civil engineers who stick to there subject.

Experienced people are hard to recruit. Road construction has for a long time been a concern of governmental organisations. Consultancy agencies in the field of infrastructure have made

Branch of engineering hardly matters to recruiters

Tamil Nadu – Chennai, July 28, 2005

K. Ramachandran
Computer Sciences and Electronics and Communications engg. are flavours of the current season Jobs are available for students with specific skill sets

Students from all branches get into high paying IT jobs Circuit branches are preferred by recruiters Even students from Civil and Architecture get into IT companies What is high in placement this year need not be so four years later

CHENNAI: It is that time of the year again — endless discussions begin between parents and children on which branch to opt for during counselling for B.E/B.Tech programmes.

There are different viewpoints: One revolves around domain skills; the second is about job prospects; the third is long term career prospects; a small number wants to go into higher education or research in one field or the other.

Some families squabble over whether branch is important or college is.

Peer pressure and media hype all point to the fact that Computer Sciences and Electronics and Communications engineering are the flavours of the current season.

Information Technology, Electrical and Electronics engineering or Electronics and Instrumentation Engineering are distant second choices.

Mechanical or Civil or even automobile engineering are not really the big hits of the season.

Reason: In campus recruitment in the ongoing season, circuit branches are getting more placements.

The IT jobs are back. And in huge number at that. Infosys, Wipro, TCS, Cognizant, HCL, Hexaware, L and T Infotech , Satyam Computers, Ramco Systems, iGate, HP, and others are taking away students in truckloads.

Academics differ
However, academics around the State say one cannot make any conclusions just because of this trend. Placement officers in campuses say jobs may be around this year for IT.

But will it remain the same after four years when this year's freshmen complete B.E or B.Tech?

Anna University's Director for the Centre for University-Industry Interaction, Mannar Jawahar, notes that IT companies have recruited 772 students this season in the four constituent colleges of Anna University.

But look at the figures: Predictably, the software companies have recruited 470 of them. However, that's not the end of the story. The software companies have also taken on board 15 aeronautical engineers, 13 automobile engineers, two from ceramics, 15 from Chemical, 24 from Civil, 13 from Geo Informatics, 20 from Industrial Engineering, 66 from Mechanical Engineering, 30 from Production Engineering, 47 from Instrumentation branches.

And an amazing 66 students have got into core (engineering, mining or civil engineering branches) companies.

This trend continues even in private colleges. For example, as K.P. Mohamed, Director Research of BSA Rahman Crescent Engineering College notes: 14 students in IV year Mechanical Branch, one from Polymer, two from Civil and six from Instrumental and Control engineering have got jobs in Infosys in campus recruitments made last month.

In all, two students from Civil and 20 from Mechanical along with 140 Crescent Engineering college students from `circuit branches' were selected by the IT firms in the last few weeks.

Role of the college
Sri Venkateswara Engineering College has put in place a system whereby at the beginning of the III or IV year, students get to opt for either taking placement through the campus or an "Option B" to pursue higher education abroad.

"We have identified 450 genuinely interested students for placement and only allow them to appear for campus interviews," says N. Nityanandan, Principal.

The college's academic adviser, Dr. S. Muthukaruppan, says this ensures that "Option B" students do not appear for interviews, take a placement offer and then disappear.

Even in this institution 222 students got placement and dozens of them in leading manufacturing sectors such as Ashok Leyland, TVS Motor, Sundaram Clayton and Elgi Equipment.

Figure 13: The Times of India (e-paper); July 28th, 2005

their entry approximately a decade ago. Most experienced engineers are therefore working within public institutions. With the benefits of working in such an organisation, these public servants will rarely shift to the private sector before retirement. Many engineers within the public sector have no urge to perform. They do not have to bother about losing there job and there wages are lowest in the branch.

Lack of engineers and demotivation will indirectly lead to bad quality of works because supervision and management of workforce is lacking. Skilled workers have more direct influence on pavement quality. Skilled workers are the most appreciated workers on Indian construction sites, especially equipment operators. They have a huge responsibility of operating expensive equipment and without them this equipment will come to a costly standstill. Unfortunately not every operator is well trained in pavement behaviour. Skills are learned on site as people start there career as machine cleaner or maintenance mechanic. Eventually they learn how to operate the machine, but their knowledge about asphalt is insufficient to recognize possible failures and their consequences regarding to the pavement performance. Observations revealed situations where operators did not work according to specified rolling patterns and applied brakes too hard so that asphalt mix was pushed upwards in front of the roller. This kind of ignorance leads to insufficient compaction and eventually to failures like corrugation. Other examples where seen with roller operators not paying attention to asphalt mix sticking to the rollers and paver screed operators who did not notice or ignored segregation which leads to ravelling. Segregation is also caused by careless loading and unloading of trucks containing hot asphalt mix (figure 14).

Figure 14: Segregation in receiving hopper of an asphalt paver finisher

Some equipment factories like Ingersoll-Rand and Wirtgen have recognized the problem and have started a solutions-centric approach instead of a product-centric approach for dealing with their customers. This means that these companies offer a training for machine operators and maintenance crew to make sure the equipment is operated like it should be operated. When operators finished their course they receive a certificate. Requirements regarding these certificates will play a role in future tenders, therefore employees who own such a certificate are very valuable and get high wages or they will find another employer. The fact that this new employer is sometimes found abroad contributes to the unavailability of skilled personnel on the Indian construction market.

Another initiative to increase India's skilled labour was set up by the state government of Andhra Pradesh. In 2002 the National Academy of Construction (NAC) was established in Hyderabad. NAC is a unique institution and one of its kind in the country for providing training facilities to the workman, contractors and engineers to improve their skills and enable them to handle large infrastructure development projects being taken up in the country both in public and private sectors. The academy through its constituent units gives training to workers in various construction trades like masons, carpenters, bar benders, formwork, plumbers, electricians, heavy machinery operators, painters and in many other trades to improve and develop skills in the respective trades

and improve the quality of works. Unfortunately there is no course for operating asphalt construction machinery. Very big contractors, like Larsen & Toubro educate their skilled workers in their own training institute as part of their quality assurance program.

Employment of unskilled labour is managed on a day to day basis. People report on the project site and selection of labourers is made on the daily need. Wages are low and therefore motivation is not a common habit. Unskilled labourers are sometimes brought into action at very crucial tasks within the construction process, like screed operators on an asphalt paver. The fact that these labourers have very little knowledge about asphalt behaviour makes this is a major cause for pavement failure. Unskilled labour is widely available in India and most of the time people are recruited within a small distance from the project area. The use of labour agents is common. The fact that most of these people are illiterate, is not seen as problem. Instructions are communicated orally and there is no language barrier, because the workforce is usually hired locally.

Insufficient human resources are a source of uncountable problems within the execution stage of a construction process. The risks mentioned in table 6 are an indication of the problems which might occur. More risks are sure to be identified if risk identification is done on a regular basis.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
EXC	GRA	08	01	Inadequate compaction	Insufficient compaction
EXC	BIT	13	04	Careless loading of trucks	Segregation
EXC	BIT	14	02	Careless unloading of trucks	Segregation
EXC	BIT	15	01	Rolling patterns not applied	Insufficient compaction
EXC	BIT	15	02	Cold compaction rollers	Asphalt mix sticks to roller
EXC	BIT	15	03	Insufficient water usage on roller	Asphalt mix sticks to roller

Table 6; Manpower related risks identified within the execution stage of a flexible pavement construction process.

9.2 Machines

Generally, developing countries are a very big market for European and American second hand machinery. India is an exception because of high import taxes and the fact that Indian's do not like second hand products. The Indian machine industry had a chance to become quite large because of the market protecting measures of the Indian Government before the 1991 economic crisis. Today's market protecting measures are less rigorous, but still influence the local machine production positively. Nevertheless Indian machinery is considered to be less superior than European or American machinery and the market of imported machinery is growing rapidly. This is stimulated by some duty exemptions within the customs act, which were introduced by the GOI in 1992 to stimulate private sector participation. These exceptions comprise the duty free import of all equipment used for projects which are financed by the United Nations or an international organisation. For other infrastructure projects of national interest an exemption from the whole on duty of customs is introduced for 21 types of heavy equipment which are listed in appendix IV.

The fact that infrastructure projects in India are quite large also stimulates contractors to buy new high quality equipment. The investment can be earned back during one project. Within many contracts requirements are also set regarding the availability and the age of equipment. Contractors are generally creative with meeting these requirements, but at least it creates a barrier to make sure most of the equipment is able to work properly. For contractors who cannot afford to buy new machinery there is an option to lease equipment to meet these requirements. This equipment is well maintained and usually comes with a well trained operator. Equipment leasing companies are still scarce, but this market is growing.

Within small construction projects it is not possible to set requirements regarding the equipment which has to be used. Small contractors cannot meet the requirements and larger contractors are not interested in this kind of projects. Transporting heavy equipment for a small project is to costly. In remote and urban areas, much work is therefore done by hand or very old machinery. The fact that a 30 year old machine is still working proves how the owners are taking care of there costly goods (figure 15). A machine is usually accompanied by several people who are responsible for cleaning and maintenance.

Figure 15; Antique roller in operation in Chennai

In respect of base failures, machines play a key role in mixing of materials and in paving the granular layers. The best equipment for mixing materials is a wet mix plant that produces a homogenous mix which is transported to the site. There, the best quality layers are produced by paver finishers and second best quality is produced by graders. Less well equipped contractors use the shovel of a backhoe loader to mix the material at site and spread it in the embankment. On projects of less importance unskilled labour is used for creating the granular layers (figure 16). Although this labour based construction is a welcome relief to a city's unemployment rate, not much should be expected from its quality. Base failures eventually lead to rutting, depressing, corrugation and all types of other failures.

Figure 16; Base layer construction in Hyderabad

Granular layers are protected by a prime coat to retain its moisture content. Between bituminous layers prime coats are applied for proper adhesion between the layers. Well equipped emulsion spray units are only seen in large construction projects. Before applying a tack coat, the surface must be clean and free of dust. Some parts of India are extremely dusty and mechanical brooms for surface cleaning have not been seen during this research.

In respect to the construction of bituminous layers, the performance of mixing plants and pavers are crucial, but transport equipment is also important. Most of the hot mixing plants in operation

Figure 17:
Left: Batch mixing plant near New Delhi
Right: Drum mixing plant near Bijapur

are drum mixing plants. This type of plant is less superior in grading materials and temperature control than batch mixing plants (figure 17). It is expected that in the near future more batch mixing plants will be used, because this type of plant is listed for duty exemption. Polymer modified asphalt is mixed at higher temperatures than conventional asphalt. Generally all plants are able to produce asphalt at the required temperatures, but some interviewed contractors claimed that their plant broke down more often. This could be a reason for contractors to keep the temperature low. Generally temperature control is said to be quite weak in India. Transport distances are often minimized by setting up a mixing plant nearby the projects, but trucks are not facilitated with insulation arrangements. It is not the availability of trucks which is seen as a problem for providing an uninterrupted flow of asphalt mix but efficient planning is. Too low temperatures leads to inadequate compaction which results in corrugation and shoving of mix. Interruption in asphalt flow leads to segregation in the hopper unit of the paver, or to a standstill. Segregation causes ravelling and standstills are sources for lateral cracks.

Most of the asphalt paving finishers in India are equipped with rubber tires. Compared to crawler mounted pavers, this type of paver has greater degree of freedom of movement. The paving width of wheeled pavers is limited to about 7 meters or else the paver will loose its traction and stability. One must keep in mind that the maximum paving width is less with modified asphalt mixes because the material is stiffer than conventional asphalt mixes. The quality of the pavement largely depends on the paving speed, the depth of material in front of the screed and the angle of the screed. Modern pavers will balance these factors automatically. Older pavers demand much more insight from its operators regarding these factors. Within the smallest projects, asphalt is mixed on site, transported by wheelbarrows and applied by hand.

Equipment for performing quality control tests is available at large construction projects. Many sites are provided with a field laboratory which is equipped with all the required devices, although calibration is said to be weak.

Machine related risks, identified within the execution stage of a flexible pavement construction process are summarized in table 7.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
EXC	GRA	04	01	Inhomogeneous mix	Unequal compaction
EXC	GRA	09	01	Insufficient prime coat spraying	Particles get washed out
EXC	BIT	10	01	Too high bitumen content	No voids in the mix
EXC	BIT	10	02	Too low bitumen content	No cohesion between materials
EXC	BIT	10	04	Temperature too low	Insufficient compaction
EXC	BIT	11	01	Surface not properly cleaned	No proper binding between layers
EXC	BIT	12	01	No smooth spray	No proper binding between layers
EXC	BIT	12	02	No smooth spray	No water-resistant layer
EXC	BIT	13	03	Temperature too low	Insufficient compaction
EXC	BIT	14	01	Temperature too low	Insufficient compaction
EXC	BIT	15	04	Temperature too low	Insufficient compaction
EXC	BIT	15	05	Temperature too high	Insufficient compaction

Table 7; Machine related risks identified within the execution stage of a flexible pavement construction process.

9.3 Materials

A flexible pavement structure is built out of bitumen, aggregate stones, sand and filler dust. These materials are all natural materials and therefore the quality largely depends on the environment in which the materials are excavated or produced.

In India, production of bitumen is done by state owned refineries through fractional distillation of crude oil (figure 18). As the quality of crude oil differs from place to place, so does the quality of bitumen. Indian bitumen tend to have a high wax content which negatively influences the bitumen in terms of viscosity, cohesion and brittleness.

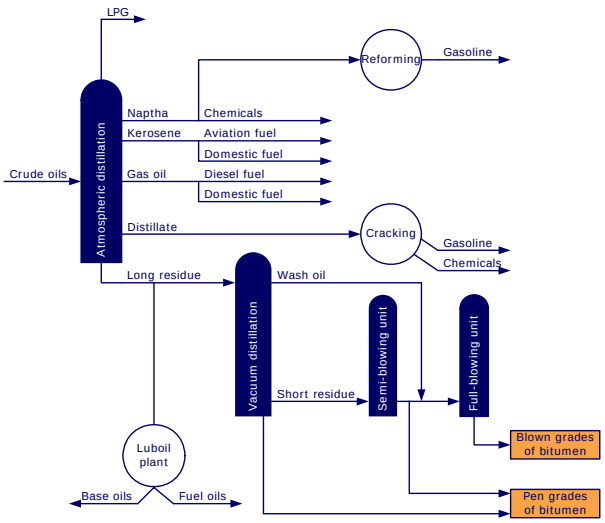

Figure 18; Distillation process of crude oil (Read&Whiteoak; 2003)

Bitumen behaviour can be improved by modifying it with additives. The aim of modification is to increase the stiffness and/or elasticity of the bitumen at high pavement temperatures and to reduce stiffness and/or elasticity at low temperatures. Polymers and crumb rubbers are the world-wide most used types of additives (de Bondt; van Rooijen; 2005). The latter is the most common used additive in India, although in the near future this might change due to the recognition of several advantages of polymers over crumb rubbers by government advising institutions.

The additive used in Sealoflex® is the elastomer Styrene Butadiene Styrene (SBS), which is a polymer and increases the elasticity at high temperatures and reduces the stiffness at low temperatures. The quality is guaranteed when leaving the Sealoflex® plant. After that the

contractor is responsible for transport, storage and processing the material. When handled properly, bitumen can be reheated, or maintained at elevated temperatures for a considerable time without adversely affecting their properties. However, mistreatment of bitumen by overheating or by permitting the material to be exposed to conditions that promote severe oxidation can adversely affect the properties of the bitumen and may influence the long-term performance of mixtures that contain bitumen (Rebbechi; 2004). Not contractor is aware of the consequences of improper handling or simply ignoring them, especially in smaller projects with less supervision.

Because of its elastic properties, PMB asphalt mix needs to be compacted somewhat differently in respect to other binders. The full level of compaction can only be achieved if rolling is done until the mix is cooled down beyond the temperature where the mix's "bouncing effect" disappears (figure 19). This can take a lot of time when the air temperature is high. Not everybody is aware of this material behaviour and proper monitoring is necessary to make sure the mix is fully compacted, e.g. by using proper calibrated nuclear density equipment.

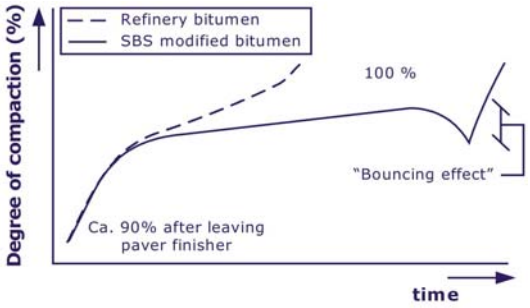

Figure 19; Schematic representation of compaction behaviour of asphalt mix built out of conventional and modified bitumen

Mineral aggregates are commonly excavated out of quarries nearby a project site. Within NH-projects a selection of appropriate quarries is made by a consultant when preparing the Detailed Project Report (DPR), considering transport distance and aggregate quality. Contractors usually obtain their aggregates out of one or more of these selected quarries, but are not restricted to them. Quality of aggregates is influenced by its physical, mechanical, chemical and petrography properties. Testing of materials is done by Bureau of Indian Standard (BIS) specifications for concrete aggregates. Specific tests for use of aggregates in bituminous works are not available and specifications regarding flakiness are extremely mild. According to IS :2386, a quite high value of 10 percent flakiness is allowed. This value represents the amount of stones which are flakey in respect to the aggregates tested. Flakey stones are flat and thin in respect to their length or width. A too high flakiness value can cause surface depressing, because the aggregates do not hook into each other. This also occurs with rounded aggregates which are also used in India. Contractors and supervising consultancy agencies keep a close eye on the aggregate supply to make sure that the materials are transported from the selected quarries. Generally, mixing plants, are built at the quarry location to minimize transport costs.

Sand is usually obtained out of rivers. As per BIS specifications sand must be free from detrimental salts and organic matter which is not always the case according to several interviewees. The required Plasticity Index (PI) for fines is said to be impossible to achieve in India.

As per Government notification, fly ash has to be used in road construction works if a project is executed within a 100 km range of a thermal power plant. Fly ash is used as filler in bituminous layers or as embankment fill material. In the latter case extra attention should be given to the moisture content. Other filler materials are industrial filler dust and dust which is collected during

the heating of aggregates in a hot mix asphalt plant. Filler provides stability and water resistance to the mastic, but is often left out of Indian mix designs.

Errors in design of bituminous mixes is one of the primary failures in India. Often the laboratory environment is different from the outside environment. Mixes often contain the wrong proportions of materials. If, for example, bitumen content is to high there are no voids in the mix and bleeding occurs. To less bitumen causes an incoherent mix which will lead to failures like ravelling and stripping. Wrong grades of bitumen are also often used which leads to mixes which become brittle in low temperatures or too soft in high temperatures.

As for all road construction materials the Indian Standards provide somewhat adequate specifications. Sometimes criteria are mild as with the flakiness of aggregate or sometimes criteria are missing. Generally criteria are met with a minimum of overlap providing no room for error. In small construction projects where supervision is minimal, there is huge risk that specifications are even ignored and the cheapest available materials are used. The risk is not there in the material itself, but more in how the material is used. Improper grading leads to unstable mixes in bituminous layers as well as in granular base layers. Wet mix macadam (WMM) is therefore preferred over water bound macadam (WBM), because the first is graded and mixed mechanically in a plant and the second by hand or a backhoe loader at the site. The required moisture content is hard to achieve in the latter type of granular layer and water is often added after laying the macadam. This causes fines to wash out.

Material related risks, identified within the execution stage of a flexible pavement construction process are summarized in table 8.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
EXC	NAT	05	01	Sand contains organic matter	Insufficient compaction
EXC	GRA	03	01	Sand contains organic matter	Insufficient compaction
EXC	GRA	06	01	Moisture content too high	Insufficient compaction
EXC	GRA	06	02	Moisture content too less	No cohesion between materials
EXC	BIT	01	01	Flakiness is too high	Aggregates do not hook into each other
EXC	BIT	01	02	Rounded aggregate	Aggregates do not hook into each other
EXC	BIT	02	01	Transporter selects different quarry	Aggregates are from inferior quality
EXC	BIT	04	01	Sand contains organic matter	Binding of materials is less
EXC	BIT	08	01	Unheated tanker	Segregation of additives
EXC	BIT	09	01	Unheated storage	Segregation of additives
EXC	BIT	09	02	Overheating of bitumen	Elastic properties disappear
EXC	BIT	09	03	Exposing bitumen to air	Oxidation of bitumen
EXC	BIT	10	03	Wrong grade of bitumen	To stiff or soft mix

Table 8; Material related risks identified within the execution stage of a flexible pavement construction process.

9.4 Methods

Methods for road construction are standardized in specifications published by the Indian Roads Congress (IRC). Clauses within these specifications sometimes refer to tests which are written down in the Indian Standards (IS) or the British Standards (BS). Which methods can be applied are written down in a contract between client and contractor. Within smaller projects, generally less sophisticated construction methods can be applied. Although all these standards and specifications are very clear, they are often ignored, especially time related specifications. The IRC guidelines regarding the application of modified binders are quite short. It is expected that experiences from the past years will soon bring a more extensive version of these guidelines.

Within a pavement structure, the bituminous layers are the costliest element. The construction of granular base layers is therefore seen as a matter of minor importance and often subcontracted, which is allowed to a maximum of 40 percent of the contract value. Many pavement failures are traced back to the base layers in which the moisture content and compaction level play a crucial role. Water bound layers are still very much used in road construction projects. This type of base layer is often mixed at site and is inferior to premixed layers. Contractors tend to save a lot of money by applying granular mixes in thicker layers than prescribed in the requirements of the IRC. The required level of compaction would then be hard to achieve. According to the specifications a compaction level of 98 percent is adequate. It would be hard to find a contractor who will try to achieve a 100 percent compaction.

The application of bituminous primers like tack and prime coats should be done uniformly, protecting the underlying layers and creating a uniform adhesion between following layers. The primers lose part of their function if they are applied by hand, which is often seen at urban or rural projects (figure 20). The required 24 hour curing time of a prime coat is said to be often ignored.

Figure 20; Applying a tack coat by hand in Chennai.

Within the construction of bituminous layers, temperature control is crucial. If temperatures are too low, the hot mix asphalt is difficult to process and it is hard to achieve full compaction, especially with stiff asphalt mixes as those containing polymer modified bitumen. Accountability regarding to temperatures is said to be generally low within construction projects. There is no chance of Sealoflex® being mixed on site or being directly heated with log fire because Sealoflex® is not supplied in drums. This guarantees an equipment based application of asphalt mix.

Planning of asphalt mix supply is essential to assure a consistent paving speed and to avoid stops. The bucket of the paver should not run out of materials to avoid segregation. Especially urban projects face problems with material supply caused by traffic jams but other projects also face

these problems by poor planning. It does not seem to concern anyone if an entire paving crew is waiting for asphalt mix.

Method related risks, identified within the execution stage of a flexible pavement construction process are summarized in table 9.

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
EXC	GRA	04	01	Inhomogeneous mix	Unequal compaction
EXC	GRA	06	01	Moisture content too high	Insufficient compaction
EXC	GRA	06	02	Moisture content too less	No cohesion between materials
EXC	GRA	07	01	Layers applied too thick	Insufficient compaction
EXC	GRA	08	01	Inadequate compaction	Insufficient compaction
EXC	GRA	09	01	Insufficient prime coat spraying	Particles get washed out
EXC	GRA	10	01	Insufficient curing time	Binder cohesion is too less
EXC	BIT	01	01	Flakiness is too high	Aggregates do not hook into each other
EXC	BIT	08	01	Unheated tanker	Segregation of additives
EXC	BIT	09	01	Unheated storage	Segregation of additives
EXC	BIT	09	02	Overheating of bitumen	Elastic properties disappear
EXC	BIT	10	04	Temperature too low	Insufficient compaction
EXC	BIT	13	01	Not enough transport capacity	Hopper runs out of material, segregation
EXC	BIT	13	02	Not enough transport capacity	Standstill in paving operation
EXC	BIT	15	04	Temperature too low	Insufficient compaction
EXC	BIT	15	05	Temperature too high	Insufficient compaction

Table 9; Method related risks identified within the execution stage of a flexible pavement construction process.

10 Operation

Indians consider their country unique in which worldwide applied products can not always be adopted. The operation of roads is a good example which shows that this is not an understatement, especially regarding the traffic conditions.

National Highways are the main interstate arteries which connect places of a relative high economic importance. In many cases, this is also the only road between cities and villages which means that all kinds of traffic can be found using this road. It has to suffer from tremendous stresses by fast traffic which has to brake for slow traffic like pedestrians, cyclists and cattle (figure 21).

Figure 21; Avoiding collision with cattle on NH 17, Goa

Overloaded commercial vehicles put a heavy burden on Indian roads. Axle loads of 24 tons are not uncommon. The fact that some vehicles are in a bad shape, worsens the damage. For example, broken suspensions could make loads hang over to one side, putting the burden on one side of the axle.

Police has limited resources to handle with these violations and even if truck drivers are caught, they can proceed their way after paying a fine, which probably ends up in an officials' pocket. The fact that there are no standards in licence plates makes it hard to act against violators. This is a huge problem for BOT operators, because they are not allowed to fine drivers themselves and it is their road which is being demolished. With the help of a weigh-in-motion system BOT operators can weigh a truck before it arrives at the toll gate to subsequently deny access to a truck. Experiments with these systems are planned in the near future in India.

Littering is common in India and drainage facilities are often clogged by waste so that they can not function properly. Drainage facilities are also blocked by home-made road entries of people living in the nearby area of a road (figure 22). Road owners are not taking care of these drainage systems, causing water to built up on the road and eventually permeate the granular layers which will loose its bearing capacity.

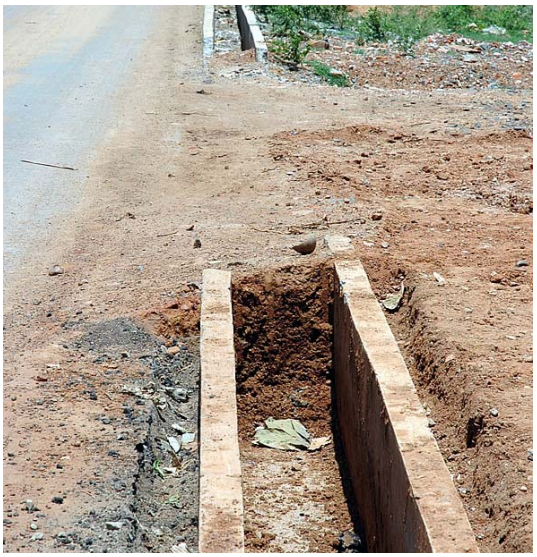

Figure 22; Blocked drainage sewer on NH5 near Chennai

The average age of cars in India is not that high, but other vehicles like busses, trucks and auto-rickshaw's can be quite old. Spillage of fuel or other chemical substances create small holes in a pavement's surface. Wooden wheels of bull karts or flat tires also

cause damages to the pavement wearing course. Generally these small damages are not repaired, or not repaired properly, so they extend to a bigger surface. Eventually maintenance is done when the road is heavy deteriorated.

Indian traffic does not move in a channelled manner. For this reason rutting is a rare failure in India, in contrast to European roads.
Risks, identified within the operation stage of a flexible pavement construction process are summarized in table 10

ID				Risk	Consequence
Level 1	Level 2	Level 3	Level 4		
OPE			01	Traffic mix of slow and fast traffic	Stress on pavements by braking traffic
OPE			02	Overloading	Bearing capacity too low
OPE			03	Clogging of drainage facilities	Ingress of water in base and sub base layers
OPE			04	Mechanical or chemical damage	Ingress of water in base and sub base layers
OPE			05	No regular maintenance of small damages	Rapid deterioration of the pavement

Table 10; Risks identified within the operation stage of a flexible pavement construction process.

Interim conclusions part III

Within the previous sections, an answer has been found on the first research question of this thesis by identifying several risks within Indian flexible pavement construction processes which eventually lead to premature failure of such a pavement. The list of identified risks is given in appendix IV. The list is complemented with the type of failure which is related to the risk.

Risk identification is a knowledge generating process which never ends. It is impossible to include all the risks. Therefore, the risks identified in the previous sections are only an indication of what can be encountered in a flexible pavement construction process and serve as a basis for risk management as a part of a company policy.

The identified risks reveal that there is a certain risk of Indian flexible pavements failing prematurely by causes which do not disappear with the application of PMB. The extent of these risks is described in the next part of this thesis.

Part IV

Risk estimation

Part IV of this thesis answers the 2nd research question by estimating the chances of occurrence and the consequences of the risks identified in part III. Risk estimation is the 2nd step within risk analysis which forms the basis for risk control.

11 Quantification of risks

The quantification of risks is expressed in a number that is determined by multiplying two factors. The first factor represents the chance that the risk will occur and the other factor represents the consequences of the occurrence. Both factors are usually scaled from 1 till 4 (Vermande & Spalburg; 1998).

risk = chance x consequences

These factors highly depend on the environment described in part II of this thesis. There can be similarities between projects, but generally India's environment is far from consistent all over the country. Table 11 describes the environmental aspects of two projects which emphasize the possible differences between projects. The first project is the reconstruction of an NH-stretch in the state of Tamil Nadu, the second project is the reconstruction of a district road stretch in the state of West Bengal.

Environmental aspect	Project 1: Reconstruction of National Highway in Tamil Nadu	Project 2: Reconstruction of district road West Bengal
Topography	South of India near the Bay of Bengal at a negligible elevation above sea level. The road connects two major cities and 50 km of stretch is reconstructed within one project.	North of India at the foot of the Himalaya at 2000 m elevation above sea level. The road connects two minor mountain villages and only 2 km of stretch is reconstructed within the project.
Culture	Indian, Tamil. Family corporate culture.	Indian, Bengali, Nepali. Family corporate culture.
Politics	Stakeholders are municipal councils, state governments, the NHAI and the WB.	Stakeholders are municipal councils and state government.
Economy	The project is partially paid out of the Central Road Fund (CRF). The other part of project costs is funded with aid of the World Bank (WB). Total project costs: Rs. 2.230.000.000 (223 crore)	The projects is funded with money collected out of state taxes. Total project costs: Rs. 11.000.000 (110 lakh)
Legislation	Contracts are set up by FIDIC specifications. Supervision is executed by an external consultancy agency.	Contracts are set up by IS. Supervision is executed by the State PWD.
Climate	Extremely hot summers and moderate winters	Moderate summers and extremely cold winters.

Table 11: Project environments vary throughout India.

Within appendix VI the individual risks identified in part III are quantified for the projects above. The quality consequences of the risks are the same for both projects with an average of 2.72. However, from a marketing point of view, the consequences of project 1 should be higher because a failure in a national project has greater impact on a brand name than a failure within a local project. The average chances of occurrence are 1.49 and 2.21 for project 1 and 2 respectively. The main problem areas which are seen across the entire country are overloading and the need for well trained personnel. The road construction sector can not deal with these problems by itself, but is dependent on legislation and education schemes of the GOI. It will take some time before these problems are solved. Planning related risks are also common in India and the source can be found in a culture which has a time perception which is rather different than in European countries.

Problems with machines and the use of inferior materials are more inconsistent throughout projects.

It is obvious that there is no uniform quantification of risks for all India's flexible pavement construction projects. Quantification should be done by the project manager for every project individually on the basis of his own past experiences which is rather subjective. For this reason "estimation" is a suitable term for quantification. During risk quantification people tend to show the following types of behaviour:

- Availability; One who has to decide tends to consider an event to be very likely if he remembers the occurrence of a similar event in the past. The more an event has occurred the higher changes of occurrence are being estimated;
- Wishful thinking; The chances of opportunities are often overestimated. ("Everything is going to be all right");
- Illusion of control; Personal control over outcomes are often overestimated.

(v.d. Does de Bye/ v. Kinderen/ Stam; 1999)

By means of statistical data, a more thorough quantification of risks can be made, but unfortunately this data is only limited available and not easily accessible for everybody within Ooms' organisation. Suggestions on how to create possibilities to learn from past projects is done in section 14.

Projects in which a lot of budget is involved, generally attract better equipped companies. Within large contracts (> Rs. 50.000.000 = ca. € 950.000) requirements are set regarding experience of personnel, availability of equipment and its age as well as financial performance. Airport projects are of a high economical importance, therefore risk will be minimized in projects concerning airport pavement structures. Large contractors are not interested in small projects and external supervision is unaffordable. Project size in respect to budget is therefore a first and reliable indication for risk quantification.

Many contractors and consultants have adopted a quality control system of their own. These systems seemed efficient and complete. Unfortunately the equipment used for measuring quality are said to be often lacking in calibration. The use of ISO 9000 and 9001 certificates is not very common within the Indian construction sector. The general opinion is that the certificate is not very useful and does not provide any information about quality, it only proves that a company is able to work by a predefined method. It gives no information about the quality of the method itself and there is limited control. Even if there is any control, people's integrity is said to be disputable.

Interim conclusions part IV

Part IV has provided an answer for research question 2 by estimating the chances of occurrence and the consequences of the individual risks found within part III. This estimation is usually done on the basis of past experiences and has proven to be a subjective activity, influenced by the environment in which a project is carried out. Therefore it is impossible to estimate risks for India as a whole, but overloading of structures and the need for trained personnel are problems which are seen throughout the entire country. Projects can be categorized by a selection of environmental similarities, which could help to make a better estimation of risks in future projects.

In India, requirements regarding personnel and equipment can be set for projects costing over Rs. 50.000.000 (ca. € 950.000). Project budget is therefore a key indicator for risk estimation in India. It can be concluded that the considered environmental aspects within airport pavement and NHDP projects are the closest to being optimal in India.

Part V

Risk control

Part V of this thesis answers the 3rd and final research question by discussing the 2nd phase of risk management: risk control. Risk control is a cyclic process which is continuously done during an entire stage of a construction process. This cycle consist out of two parts. The first part is to evaluate the status of risks which could have been changed after identification. The second step is to find appropriate responses to the certain risks.

12 Risk evaluation

Identification and quantification of risks is done at the beginning of every stage of a construction process. In the course of this stage risks might change or even disappear through certain developments in the environment or through the effects of risk control responses (figure 23). It is therefore necessary to periodically monitor the events and to customize the risk response according to the current situation. Proper responses will minimize the risks.

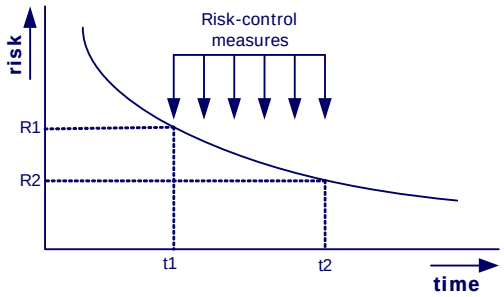

Figure 23; Risks decrease in the course of the project due to risk control measures (Vermande&Spalburg;1998)

India is developing in a tremendous pace. New techniques and a change in attitude towards construction are influencing the quality of works. Legislation regarding vehicle overloading and policies towards land acquisition will surely improve in the next few years. Risks concerning these issues will decrease in the future or even disappear.

13 Risk response

There is no response format for a risk. The perception of risk is different for every company and even for every project manager. There are four types of responses available:

- Avoid;
- Decrease;
- Transfer;
- Accept.

The choice of which response is the most suitable depends on the quantification of the risk and the necessary costs for the response (figure 24). It is also important to check a company's ability to influence the risk. Generally, the final choice for a response is made by the person who is responsible for executing the risk related task. For a 3rd party supplier, it is difficult to influence risks, because he is only responsible for a small part in the entire process. Most quality related risks are controlled by the contractor.

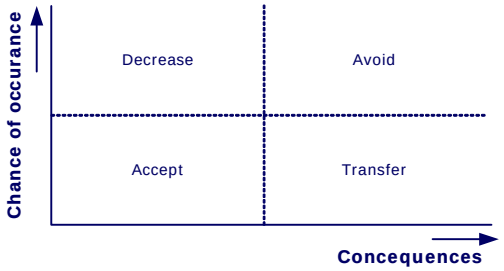

Figure 24: Response depends on quantification

For Ooms there is only one risk to respond to, which is the risk of premature failure of a pavement construction containing Sealoflex® bitumen. This risk is influenced by the risks identified in part III of this thesis, but it is not possible for Ooms to respond to those risks individually. The next sections describe a few possible responses.

13.1 Avoid

Avoiding risks should be the last resort as a risk response. Avoiding the risk of pavement failure would mean that a Ooms would decide not to sell its product. If, however, the chances of premature pavement failure is inevitable, it is better to decide not to supply the product instead of letting the product's name fall into discredit because it does not satisfy its expectations. It is a dilemma between making a quick buck by seizing every opportunity to sell the product and developing a strong flawless brand by selecting projects in which the product is sure to perform (figure 25). A company needs a bit of both to assure continuity. Instead of selecting per project, it is also possible to select contractors for long term partnerships.

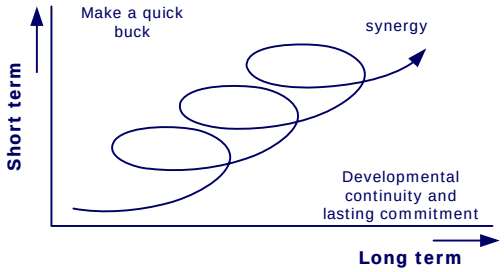

Figure 25: Dilemma between long term and short term development (Trompenaars and Hampden Turner; 1997)

Unfortunately the Indian situation does not exclude the response of avoiding projects. In fact this is already done by not supplying Sealoflex® in drums. Although Sealoflex® usually performs very well within urban areas, some city projects should be avoided to keep up the worldwide infallible product name just because some local contractors are unable to deliver a good quality pavement.

Ooms' goal is of course to sell high volumes of PMB to keep the Indian plants in operation. If the risk of failure is high, Ooms could consider selling PMB without a brand name or under a different brand name with an adapted pavement life span guarantee. This strategy is very common in food, automotive and electrical products. Two products with different brands are manufactured in the same factory with minor differences in ingredients or parts. Although the products are quite the same, customers have different expectations because of its brand name.

13.2 Decrease

The influence on the construction process of a 3rd party supplier such as Ooms PMB India is limited. Too much involvement would create the impression that Ooms is a bigger stakeholder in a project than it actually is and it would be too costly to participate actively throughout an entire project. Nevertheless knowledge is the key issue to decrease the chance that risk of premature failure will occur. Knowledge is everything that someone knows about a certain subject or area. Knowledge can be generated by transferring or communicating it to others, or it can be generated on the basis of experience (J.J.V.R. Wintraecken; 1989). Without showing off and acting like a know-it-all, Ooms could share its knowledge and experiences with its clients. This will require some level of diplomacy because clients probably have years of experience of their own and could be offended when a minor company is telling them what to do. The key issue is to create synergy between client and supplier by combining there experiences in delivering a high quality product which lives up to everybody's expectations. Knowledge about failures also allows Ooms to react quickly on a calamity and to point out that its product is not the cause of the failure.

Presently Ooms is already giving product support to new clients. Procedures for producing and processing Sealoflex® are written down in work instructions. These instructions have been altered from time to time when experiences in the field showed that this was necessary. Nevertheless these instructions contain limited information on the entire process and its risks of failure. The worldwide distribution and availability of these instructions are also considered to be inadequate.

Risks of failure can be decreased by learning of previous projects and to make experiences accessible within the entire company. Within several Dutch divisions, complaints and quality deviations are registered. Unfortunately the information is written in Dutch and international employees have no access to this information. Information is only listed and not categorized. Therefore it is difficult to determine what type of failures are common. Section 14 provides suggestions on how to improve information distribution in a way that the entire company can learn from past experiences. Trompenaars and Hamden Turner (1997) explain the importance of an information system as followed: "The hallmark of the international or transnational structure is lateral connections between activities capable of being catalysed to the advantage of the whole network".

With the application of Unihorn as a supervisor within pavement construction projects, Ooms' influence on the process can be increased. The fact that Ooms and Unihorn have recently moved to

the same office building increases possibilities for sharing knowledge. Unfortunately it is impossible to enforce road owners to contract Unihorn for consultancy and generally supervisors are contracted before a choice of bitumen supplier is made. Indian legislation does not allow consultancy agencies to design and supervise the same project. This is done to make sure design failures are not kept hidden during project execution. In India, Ooms subsidiary Unihorn is involved in both supervision and design, so it is impossible for the company to influence both within one project. By splitting up the activities between two different companies, there might be a chance that Ooms is involved in supervision and design of Sealoflex® containing roads and in this way increase the influence on quality.

A lot of Indian pavement failures can be traced back to lack of temperature control. Development of an SBS modified bitumen which does not require high processing temperatures could decrease the risks of these failures taking place.

By advising to apply thicker bituminous base courses, failures within the granular layers can be compensated. Risk related to base failures will then decrease.

13.3 Transfer

Literally transferring a risk means that risks are taken care by an external company. Usually this is an insurance company. Consequences of risks are financially compensated if they occur. It is impossible to insure the consequence of loosing market share because Sealoflex® roads are failing. However, there is a way of transferring this marketing related risk to another party in a more figurative way.

Ooms is marketing its product as a solution for deteriorating roads. One of the benefits of Sealoflex® is that it requires a minimal adaptation to the construction process. Ooms proudly presents many recommendations of contractors, consultancy agencies and road owners who testify that the product has been applied to everyone's satisfaction (appendix VII). A new client will be disappointed if the product is not performing successfully in his project, even when it is related to his own bad quality of work.

Ooms can transfer the way a client is disappointed by writing recommendations for contractors instead of contractors writing recommendations for them. It should be the contractor who is showing off that he was able to produce and process Sealoflex® asphalt mix to everybody's satisfaction. This marketing approach can be refined by awarding a yearly prize for the project manager who created the best Sealoflex® road. This brazen way of marketing could create a competition in which project managers are trying their best to improve quality, especially if the reward is desirable.

13.4 Accept

Accepting risks is inevitable in doing business. Taking risks is a chance to make profit. The big question is how much risk a company wants to take to make money. It is up to a manager to decide whether the guaranteed pavement life span can be met by accepting risks. In the course of events, evaluation of risks can point out that the risk factors have decreased in a way that acceptance is justified.

14 Implementation of risk management

Risk management as part of a company policy involves having the disposal of a consistent easy to use instrument. Which instrument is used depends on the amount of available information, the complexity of the project, the available time and the possibility to make it work within an organization.

In today's worldwide Sealoflex® projects, most experiences are only contributing to the development of persons who are directly involved. Only in the Netherlands there is some level of feedback to the department of Quality, Health, Safety and environmental issues (KAM). There are several reasons why Ooms could benefit by keeping track of experiences and share them with the entire company:

- Projects can be categorized by environmental similarities;
- Risks can be identified more easily;
- Quantification of risks can be supported by past experiences;
- Solutions to decrease risks can easily be shared and people do not have to re-invent the wheel.
- If failure occurs, causes can be quickly identified and the product's name can be cleared fast.

The goal is to learn from past experiences, so mistakes are not made twice. In other words: Create a learning organisation by communicating about errors, record them as risks and correcting them by changing the procedures. At the time that many risks and responses are recorded, an error-correcting system has been created (figure 26).

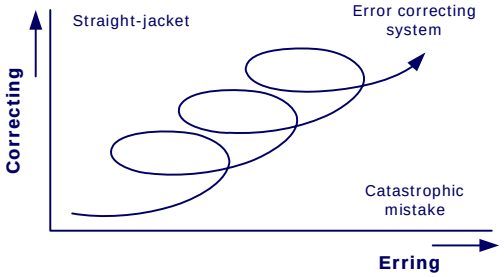

Figure 26; Process of continuing improvement (Trompenaars and Hampden Turner; 1997)

Knowledge can only be communicated when it is structured and made explicit. Information technology provides solutions for collecting data, sorting and categorising it to subsequently make the information easy accessible from everywhere in the world. Cultural differences are generally overcome because data is linear, specific and sequential. Ooms KAM department already manages an intranet site containing information about Ooms' subsidiaries (figure 27). Several risk analyses are available on this site regarding safety issues. Unfortunately this site is only available in Dutch and only focussed on the construction environment in the Netherlands. Nevertheless, the site can easily be expanded with an English information system containing all types of information of past projects. Many international operating companies use an intranet

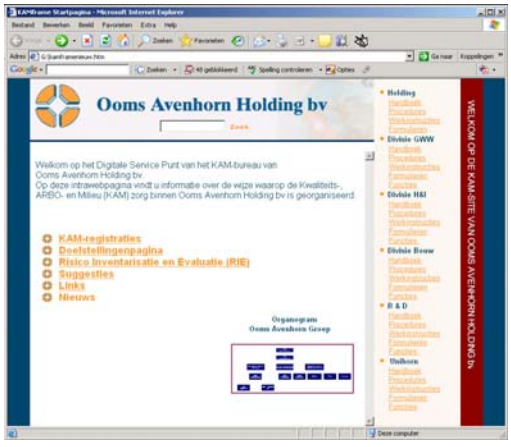

Figure 27; Intranet Ooms Avenhorn Groep

to inform employees about latest developments and to create a possibility to learn from each other. Besides creating a learning organisation, such a system contributes to a sense of commitment by informing employees about the company's activities. Ooms employees in India have little knowledge about other Ooms' activities then the production and selling of Sealoflex®, a phenomenon quite common within other globally operating companies. With the help of a Content Management System (CMS) users can be divided into several grades of information system users with specific rights for accessing and adding information. The main advantage of an information system is the fact that information can be extracted by many different approaches and can be visualized in different ways fitting in the user requirements. Information systems can provide information whenever necessary without restrictions. Information which is stored a long time ago can be accessed in a matter of minutes in the same way as it was originally entered. Figure 28 shows the communication of people with and without an information system.

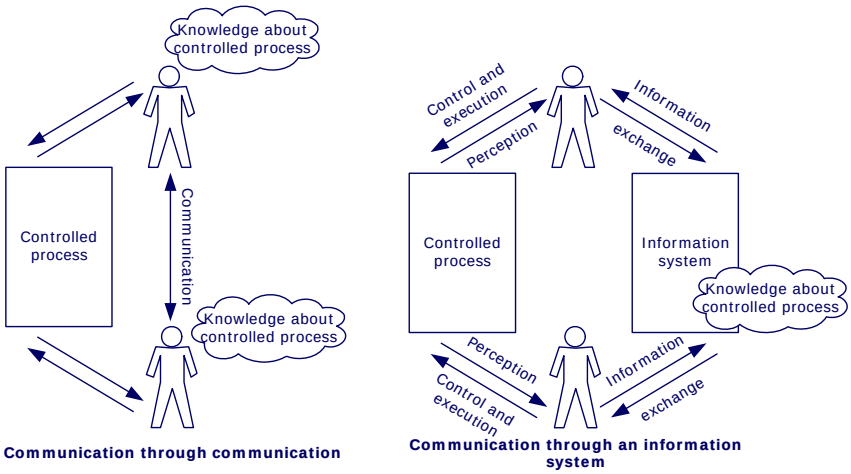

Figure 28; Information exchange through direct communication and through an information system (J..J.V.R. Wintraecken; 1989)

Balance must be found between gathering enough information and between a tool which does not require too much user time. The first step is to analyse which data is useful to collect and how this data is related to each other. At least information should be collected about projects, processes and identified risks. The relationship between these objects is visualized with NIAM in figure 29.

Figure 29; Relationship between 3 main data objects visualised with NIAM

The following rules are visible in this diagram:

- There are processes
- There are risks
- There are projects
- Processes can involve one or more risks
- A risk always occurs in a process
- A risk can not be related to more than one process
- A risk can occur in one or more projects
- A project can involve one or more risks
- A process can involve one or more risks

Information about processes should contain working instructions describing how the process should be executed. Risks should provide information about consequences and controlling measures. Project information should provide insight where and when projects have been executed, what the project has been about and who has been involved. A NIAM visualisation of a complete information system is suggested in appendix VIII. The environmental aspects discussed in part II of this thesis are clearly recognized in this system. Information regarding culture is difficult to structuralize in an information system. Trompenaars and Hampden Turner (1997) use four metaphors to distinguish different cultures: Incubator, guided missile, family and Eiffel tower (figure 30). Although these types do not occur uniformly, it is possible to select a type which most resembles the project organisation. Various literature claims that India's corporate cultures generally resembles the family metaphor.

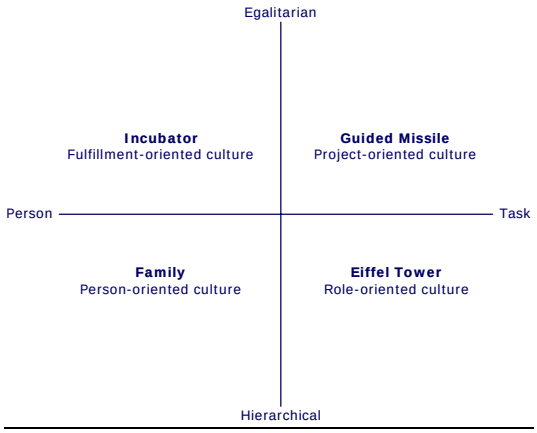

Figure 30:
Corporate images (Trompenaars&Hampden-Turner;1997)

The system is linked to other information systems regarding clients, relations and employees, so there is a possibility for employees to contact their colleagues if they require more specific information about a certain project.

The second step in creating an information system is technical implementation. The Ooms Avenhorn Groep has the disposal of a powerful network system which can be accessed throughout the world by internet. The office in India is equipped with state of the art network facilities which can provide access to the system in the Netherlands. The means are available, but finding out how to use them is not part of this thesis.

Experiences with risk management have revealed that after all arrangements have been made, risk control is often set aside. Deadlines are more important than controlling negative events that might happen. It is therefore essential to create a risk aware organization, which does not consider risk analysis as a one time activity (v.d. Does de Bye/ v. Kinderen/ Stam; 1999). If risk management works out well for the Sealoflex® product, it should also be able to be implemented in other business units of Ooms with minor alterations. Besides quality related risks, other risks can also be included regarding money, organisation, time and information e.g. know-how. Ooms Polymer Modified Bitumen India Pvt. Ltd. has already experienced difficulties with obtaining permits, getting approvals for new products and lack of payments in India. These kind of problems all form a risk for a company's existence. It could be useful to implement other type of risks in a risk management tool, but a balance needs to be found between the amount of information which is useful and the amount of information which is workable. Keeping track of too much information will become a burden for people who have to work with it.

Risks can be identified using various levels of detail. The process visualized in the SADT diagram of appendix II is drawn up in a rather rough level. Processes of asphalt mixing and asphalt paving can be visualised separately for different types of plants and pavers. Within this thesis the detail has been limited to create a more structural view of the whole process. Extension of detail can be useful when delicate risk factors are implemented in the system. A detailed visualisation of the asphalt mixing processes within a batch mixing plant and a drum mixing plant are given in appendix IX. In this level of detail it is possible to point out exactly where a risk such as temperature control is crucial. This positively influences the level of insight in a process, but negatively influences the level of process overview.

Interim conclusions part V

Risk control is a cyclic process which comprises two steps. Within the first step, risks are evaluated for their status to anticipate on environmental developments and risk control tools which could have influenced certain risks.

The second step is to apply risk control tools. Risk management literature provides four tools: Avoid, decrease, transfer and accept. Within the previous sections suggestions are given on how Ooms can make use of this tools to cope with the risk of loosing their infallible brand name by applying its product in India. Because of its limited influence on the construction process, the options are limited.

- Risks can be avoided by not selling the product;
- Risks can be avoided by not using a brand name or using a different brand name for high risky projects;
- Risks can be decreased by sharing information about risks and learn from past projects through the collection and structuralization of experiences in an information system;
- Risks can be decreased by enlarging the influence on the project by involving other Ooms subsidiaries;
- Risks can be decreased by development of an SBS modified bitumen which does not require high processing temperatures;
- Risks regarding granular base failures can be decreased by applying thinker layers of bituminous base courses;
- Risks can be transferred to companies which are responsible for the application of Sealoflex® by a change in marketing strategy. This could also give an impulse to improve their quality of works.
- Risks can be accepted.

Which response is applied depends on the quantification of the risk and the perception of the manager involved. The manager has to decide whether a contractor has a capable workforce and capable equipment to apply Sealoflex® the way it should or whether the traffic parameters in the design are chosen well and overloading and traffic growth is taken into account. This puts a quite heavy burden on the managers involved, but with an information system he can get information about how responses worked out in past projects. Besides that, an information system can also help to identify and quantify risks. The fact that an information system is also identified as a possible tool to decrease risks means that every stage of risk management will avail by the use of an easy to use up-to-date information system.

An information system is available within Ooms, but it contains limited information about past projects and risks concerning safety features are the only risks recorded. On top of that, the information is only available in Dutch and focussed on the Dutch environment, so international employees can not use it.

Part VI

Conclusions and recommendations

Conclusions

Within almost every stage of the Indian flexible pavement construction process, risks have been identified which can cause a pavement not to satisfy its expectations.

The main identified quality risks are:

- Design stage
  - The use of wrong traffic parameters for traffic growth and axle loading, which will eventually lead to structure overloading;
  - Wrong designed drainage facilities;
- Preparation stage
  - Delays caused by inefficient land acquisition and relocating of utility cables and pipelines, caused by bureaucracy and bad records;
- Execution stage
  - The deployment of manpower lacking in skills, caused by a lack of human resources and a too much projects;
  - The use of employment based methods for activities which should be done with equipment, caused by economic circumstances;
  - The use of bad quality materials, caused by unavailability or high costs of good quality materials and bad project supervision;
  - The use of wrong construction methods, caused by bad instructed personnel and economic circumstances;
- Operation stage
  - Overloading of commercial vehicles, caused by lack of force on legislation;
  - Bad maintained vehicles cause mechanical and chemical damage and unequal axle loading;
  - Bad maintenance of drainage facilities.

Requirements and specifications concerning the application of PMB is not very detailed, but the Indian Roads Congress (IRC) is working on that matter.

The chance that a flexible pavement will fail prematurely largely depends on the project's environment. India's environment varies throughout the country. Therefore the chance of premature failure can not be determined for the country as a whole. Quantification of risks is subjective and done on the basis of past experiences. By structuring data of these experiences, environmental similarities can be found and used for the prediction of risks within future projects.

Airport projects and projects within the NHDP are considered to be of the best quality in the country because a lot of money is invested by several stakeholders. This is also the case with many state highway projects, although in economic weaker states, like Bihar and Assam, there are less means available for construction, which reflects in the quality of works. Quality within other road projects, like district and city roads is considered to be the most variable, but generally low.

Overloading is seen as the one of the biggest risk for Indian pavements. Unfortunately the sector itself has not much influence on this risk and has to rely on strict control by the GOI, just as with education. Governmental schemes have resulted in training, education and large equipment investments by contractors, but not every part of India has benefited from these schemes.

Risks related to planning and quality control are also quite common, but these risks can be controlled by the sector itself. The use of proper calibrated measuring equipment is one of the primary required developments towards pavement quality.

If a governmental organisation tenders a project with a budget of Rs. 50.000.000 (ca. € 950.000) or more, it can set requirements regarding personnel and equipment from which the pavement quality benefits. Project quality also benefits from supervision which is executed by a private company instead of a public organisation.

Reflection

Results

The original objective of the research was to identify and quantify risks of premature failure. To achieve this goal, research was done using a risk management methodology. Risk management is a continuous process and the outcome is generally based upon statistical data and past experiences. Statistical data is not available for the subject of this thesis, therefore data was gathered through interactions with people experienced in Indian road construction and from researchers' experiences which were gained during site visits. Data was gathered over a period of two months of which most of the visited projects were stopped because of monsoon. The presented data is therefore limited in its extent and represents a situation at a certain moment in time. The situation, however, is continuously changing, which underlines the necessity of risk management being a continuous process.

The fact that data was gathered from people with all kinds of disciplines and the fact that projects have been visited which vary from small local city projects to large national highway projects, has contributed to the creation of a wide overview of the Indian road construction sector. The first objective was met by the identification of several risks throughout the entire construction process. The second objective, however, has proven to be difficult to meet. The identified risks are evaluated on the basis of experience gathered in a period which is too short to make a reliable estimation.

This thesis can not be used as a handbook for operating in India but it can be used as an overview of relevant characteristics of the Indian construction process which form a threat for the marketing success of Sealoflex®.

Process

Before research had started, the quality of roads was expected to be a matter of the construction sector. Only in the course of the research it became clear that it is a matter of the entire country's development. Legislation, public awareness, education and economic conditions are examples of factors which eventually influence the quality, but are impossible to be managed by the construction sector alone.

Executing this research has proven to be a time consuming activity. The research period could have been shortened by assuming that deadlines would be met. At times, the final arrangements were only made after a deliverable had been finished. It is better to plan ahead in anticipation of final approval. For example: The ticket for India was booked after the interim report was approved. It took a month to prepare the final arrangements.

Making appointments in India is difficult for someone who is used to the Dutch standards of making appointments. The only way of getting an appointment is to barge into an office and claim some time or let somebody call who is acquainted with the person in question. This was a rather

underestimated aspect of the research, but with the help of the Ooms India employees the meetings have become satisfactory.

Finally it can be concluded there is not so much difference in working abroad or in someone's native country. Nevertheless, being in an interesting different environment twenty four hours a day is a challenge worth the effort.

Recommendations

The risk management methodology provides four different responses to risks, which are avoid, decrease, transfer and accept. Ooms PMB India Pvt. Ltd. is a 3rd party supplier and has limited influence on the construction process. Nevertheless, this thesis provides several suggestions about how to make use of these responses. In this way Ooms can control the risk of harming a good brand name through premature failure of Sealoflex® containing flexible pavement structures. With all the proposed responses, specific research should be done before implementation. The suggested responses are:

- Avoid the risk by not selling the product to projects with a high risk factor;
- Avoid the risk by adopting another brand name for projects with a high risk factor;
    - Research should be done concerning the effects on marketing and pricing. If Ooms is introducing an inferior brand of PMB, this should be done at a lower price. This is only possible if there is a evidently difference between the products, or else all clients will only buy the newly introduced PMB and Sealoflex® is not longer sold.
- Decrease the risk by setting up an information system which keeps track of past experiences. Structuring data about projects, their successes, failures and environments makes it possible to anticipate on risks within new projects by comparing them with projects from the past.
    - Research should be done regarding the cost and benefits of such a system;
    - Research should be done regarding technical implementation;
    - Research should be done regarding the willingness of employees to provide information on a regular basis to keep the system up to date;
    - Research should be done regarding the extent of the system;
- Decrease the risk by developing an SBS modified bitumen which can be processed at the same temperature as conventional bitumen. Such a product minimizes the occurrence of temperature control related failures.
    - Research should be done concerning the costs, benefits and feasibility of the development;
- Decrease the risk by creating possibilities to increase Ooms' influence on the construction process by splitting the design and supervision activities of Unihorn.
    - Research should be done concerning the costs, benefits and legislation conditions.
- Decrease the risk by advising to apply thicker bituminous base layers in flexible pavements. This creates opportunities to compensate failures caused by improper granular base layer construction;
    - Research should be done concerning the costs and benefits and the clients' willingness to invest in more material;
- Transfer the risk by a change in marketing strategy in which the client is proud to be able to apply the product instead of the supplier being proud to have his product applied. This strategy could be complemented with a "best Sealoflex®-applier" award to stimulate performance;
    - Research should be done concerning client approach;

- Accept unavoidable risks with minimal consequences.

Within this thesis, the emphasis lies within the implementation of an information system for employees and clients. Such a system is not only a tool for decreasing risks, but is also a necessity for proper identification and quantification of risks and thus a necessity for implementation of risk management as part of a company policy. Ooms already uses an information system, but this is only available in Dutch, focuses on the Dutch construction environment and contains limited information. The existing system should be expanded with an English system which contains information about processes and its related procedures and risks. The system should be complemented with information about past projects so employees are able to learn from past experiences and apply proper risk control measures. The ultimate goal is to create a learning organisation. Risk management should therefore become a continuous process of analysis and control.

Abbreviations

Abbreviation	Description
AAI	Airports Authority of India
ADB	Asian Development Bank
AIR	All India Rank
BIS	Bureau of Indian Standards
BOT	Built Operate Transfer
BS	British Standard
CBR	Californian Bearing Ratio
CMS	Content Management System
CRF	Central Road Fund
CRRI	Central Road Research Institute
DPR	Detailed Project Report
e.g.	exempli gratia
FIDIC	Fédération Internationale des Ingénieurs des Constructions
GATE	Graduate Aptitude Test in Engineering
GQ	Golden Quadrilateral
HDP	Heavy Duty Pavements
IIT	Indian Institute of Technology
IRC	Indian Roads Congress
IS	Indians Standard
JBIC	Japan Bank of International Cooperation
JEE	Joint Entrance Examination
KAM	Dutch abbreviation of Quality, Health, Safety and environmental issues
KSHIP	Karnataka State Highways Improvement Project
MORTH	Ministry of Road Transport and Highways
NAC	National Academy of Construction
NHAI	National Highway Authority of India
NHDP	National Highways Development Plan
NITHE	National Institute for Training of Highway Engineers
NS-EW	North South - East West
PMB	Polymer Modified Bitumen
PMGSY	Pradhan Mantri Gram Sadak Yojana
Pvt. Ltd.	Private Limited
PWD	Public Works Department
RIDCOR	Road Infrastructure Development Company of Rajasthan
Rs	Rupees
SBS	Styrene Butadiene Styrene
SPV	Special Purpose Vehicle
TNRDC	Tamil Nadu Road Development Company

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Ministry of Road Transport & Highways (MORTH)	Annual report 2005	2005	New Delhi	Government of India

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Description	Address
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Airports Authority of India (AAI)	www.airportsindia.org.in
India Meteorological Departement (IMD)	www.imd.gov.in
Los Angeles Times	www.latimes.com
Ministry of Road Transport and highways	morth.nic.in
National Highways Authority of India (NHAI)	www.nhai.org
The Times of India	www.timesofindia.com
World Bank	www.worldbank.org

Appendices

Appendix I; Visited persons and introduction letters

Name	Position	Company/institute	Topics discussed
Dr. S. Bose	Deputy Director	Central Road Research Institute (CRRI)	• Common failures in Indian flexible pavements • Contracts
Mr. R.S. Shukla	Chief Engineer (Materials)	DS Construction	• The appliance of PMB in India • Production process of asphalt mix
Mr. R. Raina	Superintending Engineer	New Delhi Municipal Council (NDMC)	• Tendering process • Delhi construction projects • Contractor's performance • NDMC Supervision
Dr. A. Veeraragavan	Professor	Indian Institute of Technology (IIT)	• Human resources • IIT Programme • Construction equipment • Supervision
Dr. S. Kalidindi	Professor	Indian Institute of Technology (IIT)	• Contracts • Human resources • Construction equipment • Supervision • Duty exemptions
Dr. B.S. Sarma	Head Research & Development	Larsen & Toubro Limited (L&T)	• L&T projects • L&T in house training • Contracts
Mr. K.S. Reddy	Senior Construction Manager	Larsen & Toubro Limited (L&T)	• Land acquisition • The appliance of PMB in L&T projects • Construction equipment • Supervision • Construction materials • Maintenance of roads and drainage facilities

Appendix I; Visited persons and introduction letters

Name	Position	Company/institute	Topics discussed
Mr. K. Jagadeesh	Project Consultant	L&T – Ramboll Consulting Engineers Ltd	• Human resources • Subcontracting • Funding • Contracts • Legislation • Innovation • Construction equipment
Mr. K. Malmarugan	Head – New Initiatives	Tamil Nadu Road Development Company (TNRDC)	• Land acquisition • Utility cables an pipelines • Legislation • Construction equipment • Pavement failures • Human resources • Private Public Partnerships • Project funding
Mr. A.S. Babu	Highway Engineer	Tamil Nadu Road Development Company (TNRDC)	
Mr. N.L.R. Peshve	Project Director	Karnataka State Highways Improvement Project (KSHIP)	• Contracts • Project funding
Mr. N. Chandrasekhar	Head – Technical	Bangalore International Airport Ltd. (BIAL)	• Construction methods • Construction equipment • Construction materials • Road maintenance • BOT projects in airport development
Mr. M.K. Aggarwal	Project Advisor	Nandi Infrastructure Corridor Enterprise Limited	• Human resource development • Contracts • Projects funding • Pavement failures
Mr. M.K. Kumar	General Manager - Highways	Aarvee Associates	• Construction methods • Construction materials • Construction equipment • Human resources • Pavement failures

Appendix I; Visited persons and introduction letters

Name	Position	Company/institute	Topics discussed
Prof. K.B. Chandra Sekhar	Director	National Academy of Construction (NAC)	• Human resource development • Project supervision
Maj. C.L. Verma	Teamleader	Feedback Turnkey Engineers	• Contractors performance • Quality control
Mr S. Sunder Reddy	Project manager	R.K. Shiva	• Construction equipment • Human resources • Supervision
Mr. Prabash Singh	Member Engineer	Delhi Development Authority	• Pavement management • Land acquisition • Innovation • Contracts
Mr. V.K. Sachdev	Chief Engineer (Mechanical)	Ministry of Shipping, Road Transport & Highways	• Construction equipment • Duty exemption
Mr. S. Tanpure	Manager Technical	National Highways Authority of India (NHAI)	• NHDP • Pavement management • Pavement design
Dr. T.V. Krishna Murthy	Director	EMA Unihorn India Private Limited	• Project design • Project management and supervison • Legislation • Construction materials
Dr. L. R. Kadiyali	Chief Executive	L. R. Kadiyali & Associates	• Human resources • Quality control • Indian specifications • Construction equipment

University of Twente
The Netherlands

Dear Sir / Madam,

This letter introduces one of our students and I kindly request your cooperation in his research project that he is carrying out in the framework of his graduation assignment of the Master of Science programme.

Mr. Remko Put studies Civil Engineering & Management at the University of Twente and he is specializing in construction process management. Remko has also followed some courses of the Technology & Development Group of the University of Twente because of his interests in international business, in particular concerning civil engineering in non-western countries.

Remko is momentarily in the final stage of his studies which concerns a Master graduation assignment in cooperation with Ooms Avenhorn Holding India Pvt Ltd. His assignment is to gather information and experiences in India on the construction of heavy duty pavements containing modified bitumen. This information will be used for his Master thesis, which will describe the aspects in the construction process that deserve extra attention when constructing such a pavement.

Remko hopes to gather information by interviewing people who have experiences with Indian road construction projects. He would also like to visit some ongoing projects by himself if this is possible. I therefore kindly ask your cooperation in his research.

Yours truly,

Dr. Sirp J. de Boer
supervisor
International Management section
University of Twente
the Netherlands

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Ooms Avenhorn Holding India Private Limited

Dr. K. Ramamurthy
Managing Director

OAHI/DrKR/05/0693
13th June 2005

Mr. Albert Brunner
Chief Executive Officer
Bangalore International Airport Ltd.
Khanija Bhawan, Ground Floor
#49, Race Course Road
Bangalore – 560 001.
Ph : 080-22081280

YOUR ESTEEMED ORGANIZATION HAS BEEN CHOSEN FOR CASE STUDY & COLLECTION OF DATA

Sub : **Influence on the construction process quality – Construction of heavy duty pavement structure in India**
Re: **Mr Remko Put, Our Technical officer from the Netherlands**

Dear Sir,

INTRODUCTION IN BRIEF:

We are a reputed group of Holding companies under the name **Ooms Avenhorn** Groep bv (Ooms); *established* in the Netherlands in **1913**. The Group's activities include engineering, contracting, industrial contracting, consultancy, construction, manufacturing and related civil engineering activities, products and services.

Ooms has its own **Research Centre** where several modified products for road, airport and construction works have been developed. Some of the products, such **as** polymer **modified bitumen based on polymers**, resins, rubber and chemical additives are used to ensure chemically balanced binders with considerably improved Mechanical and Rheological properties. The **Polymer Modified Bitumen** group, the so called **Sealoflex products and systems** belong to a package of such products and services. The **Rational Management Systems**, including pavement design and performance models, are used in predicting the design life of products and pavements accurately. This gives also the **most cost effective design** options for road and airport pavements

Through working in many countries (our presence in over 15 countries), we have been able to synthesize our R & D base thro' convergence of our expertise. Various products most of them developed with the company's own expertise, are used to increase the life span of asphalt concrete pavements.

YOUR ESTEEMED ORGANIZATION CHOSEN FOR CASE-STUDY :

I wish to inform you, as part of our on going research needs, one of our technical officers from Ooms bv. Group, the Netherlands, Mr. Remko Put, currently doing Masters at the University of Twente, is coming over to India to spend four months here for completing his research assignment.

505, Bhikaji Cama Bhawan. 11, Bhikaji Cama Place, New Delhi - 110 066.
Tel : +91-11-26160553 / 2853 / 26163436 Fax : +91-11-26164323
E-mail : ooms@oomsindia.com Website : www.oomsindia.com

The topic he has chosen is "**Influence on the construction process quality by 3rd party suppliers - Construction of heavy duty pavement structure in India**" I enclose, in ANNEX II, a copy of extracts taken out of his interim report from which it may be seen that a good amount of work will be done on the risk management of construction contracts with particular accent on quantification as well as evaluation of such risks and how we need to respond to these risks.

The topic itself is quite interesting and I seek your help in extending your support to such an exercise.

While in India, Mr. Remko Put will be conducting Interview-Surveys with organizations of repute like yours, which survey-results will form part of data collection for analyses. **I have pleasure to inform you that your esteemed organization has been chosen for conduct of survey by our Group's Mr.** Remko Put.

This mail/letter is primarily to keep you informed of Mr. Remko Put's programme to India starting from July 1st week. He would like to do the data collections for which interviews will be conducted by him when he is with your organization. The data collections will include the following:

AS REFLECTED IN ANNEX I (this is only a small brief)

REMKO'S VISIT – DATES WITH YOUR ORGANIZATION :

Mr. Remko Put will be with your organization from **5th to 6th Aug. 2005**.

REQUEST :

Can I suggest and request the following:

You may depute one of your enterprising officers to be Mr. Remko Put's guide and coordinator; who will help him to interact with all those who matter and who could contribute to the research and data collection. Can I be helped out in the above intellectual exercise being carried out and can I get the name and phone number of your officer with whom I can get in touch on the above requirement of ours?

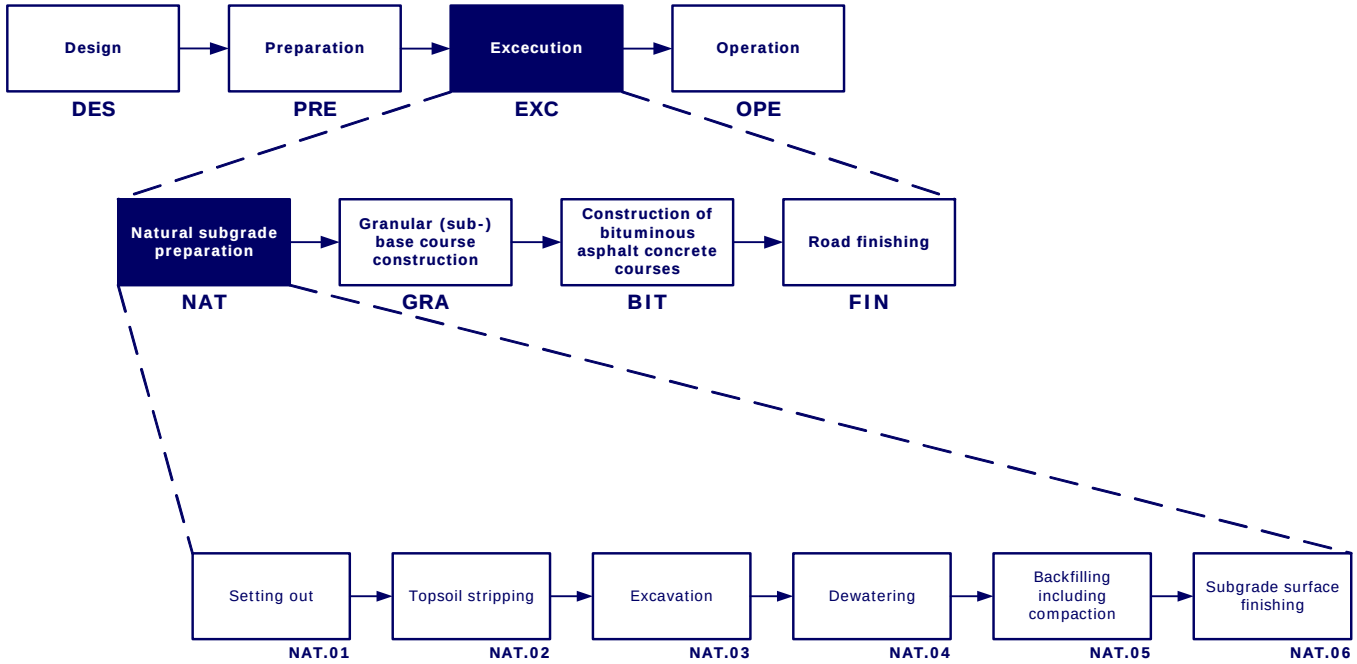
Thanking you in advance.
With best regards,

Yours truly,
For Coms Avenhorn **Holding India Pvt. Ltd.**

(Dr. K. Ramamurthy)

Encl: as above ANNEX I & II

Appendix II; SADT diagram of a pavement structure construction process



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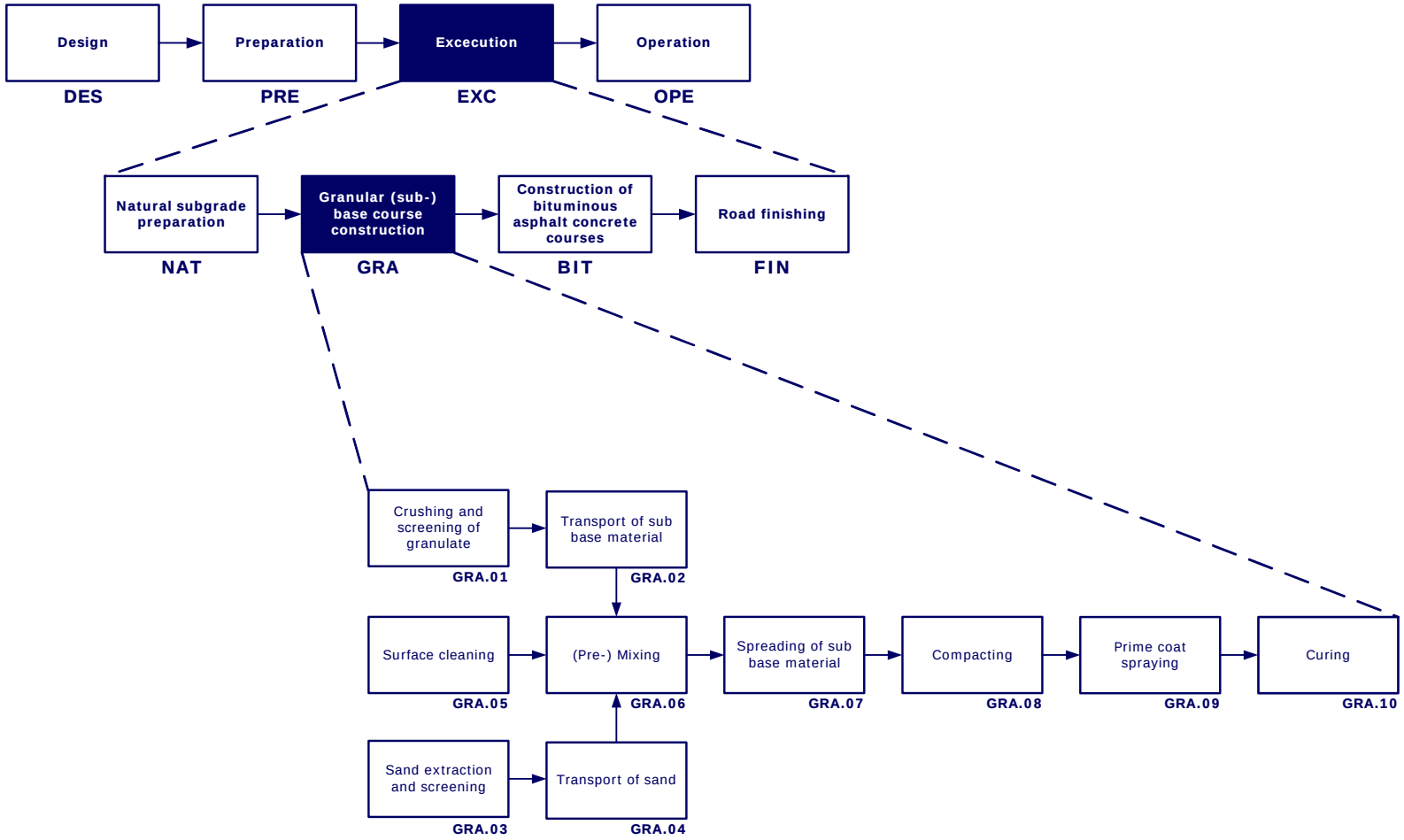

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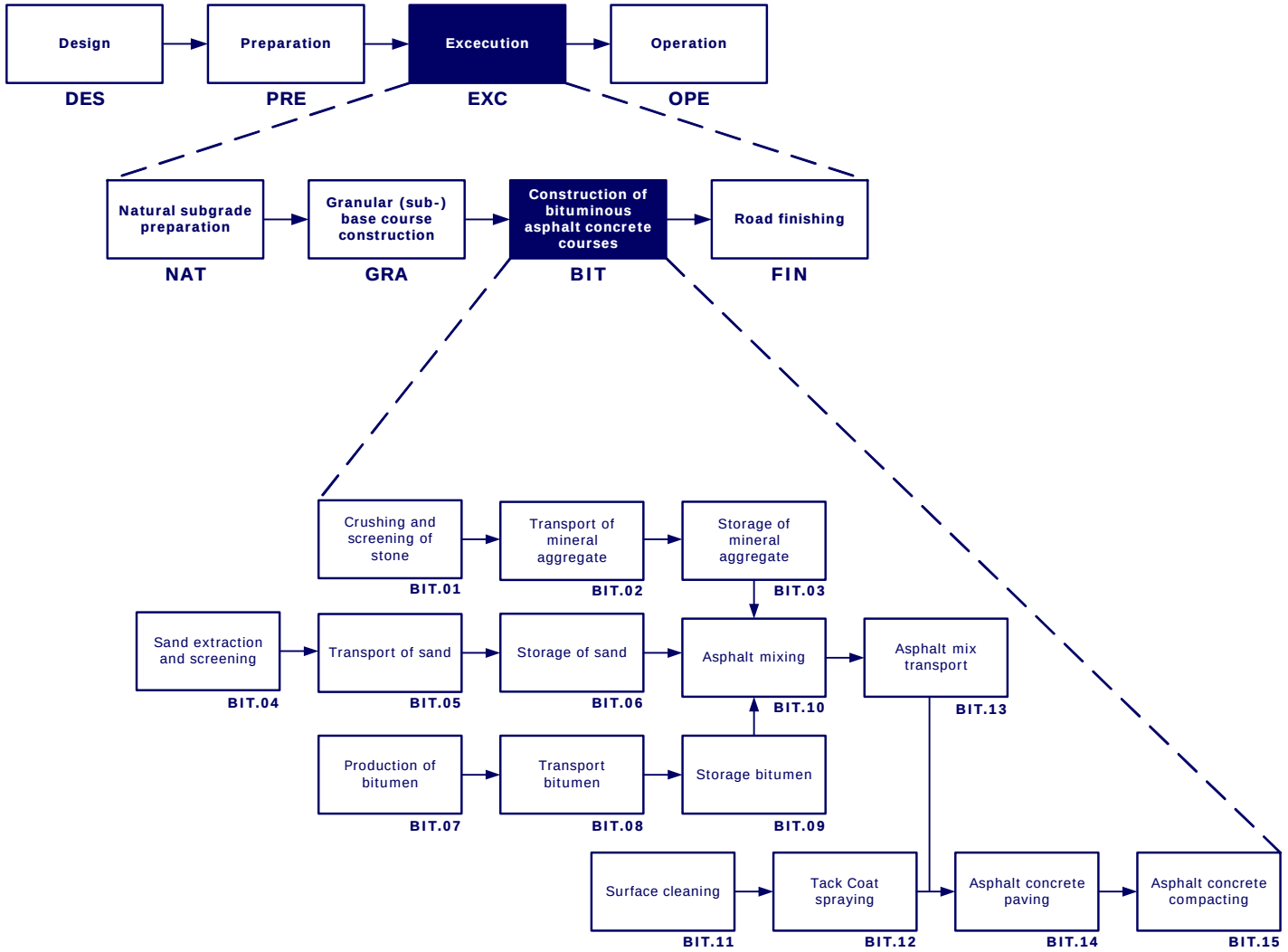

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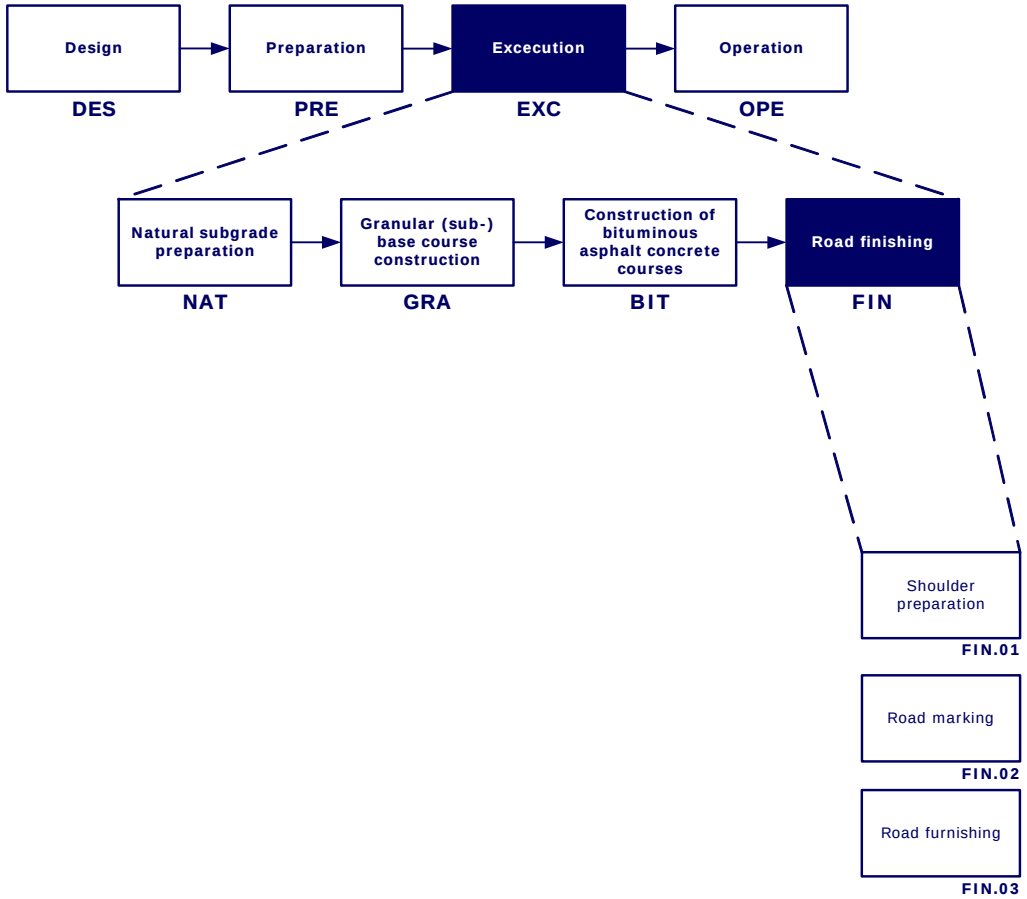


Contents

1 Topography

India is worlds 7th largest country with a surface area of 3.165.596 km^2 covering 2.4% of the worlds total surface area (figure 1). The country supports and sustains 27% of worlds' population with 1.065.070.600 inhabitants in 2004, which is the 2nd largest population of the world. In 2002 28% of the population lived in urban areas. The largest cities are Mumbai (Bombay), Kolkata (Calcutta), Delhi and Chennai (Madras) with 16.4 million, 13.2 million, 12,8 million and 6.4 million inhabitants respectively in 2001. (Bronzwaer; 2004)

Figure 1; India (Bronzwaer; 2004)

The country is divided in 28 states and 7 union territories. Every state is then divided in several districts. In total, there are hundreds of districts in India.

For a vast developing country like India, transportation is a key element for achieving development. For many decades the Indian railway system was the showpiece of the Indian transport systems consisting of more than 62.700 kilometres of railway. Nowadays the railways cannot cope with the demands of the immense growing transport sector and services are negatively affected by the urgent need for maintenance and the inadequacy of the computer systems (Boon 1996). Other means of transport are therefore growing rapidly, especially air and road transport.

The Ministry of Civil Aviation has provided the Airports Authority of India (AAI) with the task of managing a total of 92 airports and 28 civil enclaves within military airfields. From the total amount of airports only 61 are operational. The remaining are lying unutilised, at best handling occasional aircraft operations. The 4 main international gateways are the airports of Mumbai, Delhi, Chennai and Kolkata. Several other airports have limited international services.

Air traffic in India has grown more than 125 percent in the last decade. The growth until 2010 is expected to be much bigger as is shown in table 1.

Type of air traffic	Yearly traffic in 2004	Expected Yearly traffic in 2010
Passengers	40.000.000	90.000.000
International freight (metric tons)	700.000	2.400.000
Domestic freight (metric tons)	300.000	1.000.000

Table 1; Expected Indian air traffic growth to 2010 (Website EVD; 2005).

According to the Times of India, passenger traffic even rose with 22 percent during the last fiscal year of 2004-2005 which ended in March. The growth is caused by two factors:

- The introduction of low cost airliners which made it possible for more Indians to fly;
- A new open skies policy which contributed to the growth of international traffic.

As a result of this growth the current nine Indian airliners placed orders of 350 aircraft in the first half of 2005 which is more than 50% of all global aircraft orders in that period (figure 2). This immense growth in air traffic will require huge developments in airport infrastructure which already has trouble keeping up the pace.

India Buys half of the world's planes

RUMI DUTTA HARDASMALANI

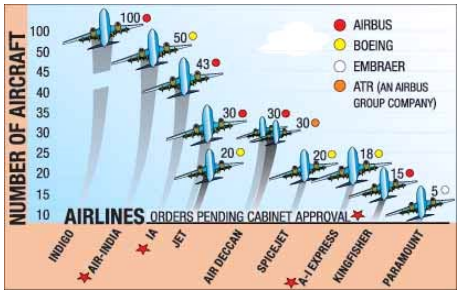
TIMES NEWS NETWORK [FRIDAY, JUNE 17, 2005 10:38:34 AM]

MUMBAI: Nine airlines. 350 aircraft. Funding and infrastructure a big question mark. This sums up the booming Indian aviation sector.

In the last six months, private Indian airline companies have placed orders for 250 aircraft, representing 43 per cent of the total global orders placed with aircraft manufacturers Airbus and Boeing.

Add the 93 planes that national carriers Air-India and Indian Airlines are expected to order, and India's share of the global aircraft market zooms beyond 50 per cent. (Globally, Airbus and Boeing have secured combined orders of 573—Airbus 296 and Boeing 277— compared with 647 in the whole of last year.)

The aviation world stands divided over India's ability to sustain such explosive growth. Noel Forgeard, Airbus president & CEO, is reported to have said at the Paris air show, 'China and India should be the drivers of growth in the future," a view that IATA director-general Giovanni Bisignani shares.



However, Boeing's Dinesh Keskar is not amused."The world is sceptical about the way Indian new-born carriers are ordering planes. How are they going to get so many pilots, where is the infrastructure?" he asked.

Look who's buying these birds in India. Complete unknowns—until even a few days ago. IndiGo Air, promoted by Delhi based air travel services company InterGlobeEnterprises, on Thursday announced the acquisition of 100 A-320 aircraft.

Figure 2; The Times of India (e-paper); June 17th, 2005

An AAI analysis revealed that 5 national airports have to be converted to international airports and 9 airports have to be expanded to get rid of congestion. Many other airports need minor upgrades within ground handling facilities and cargo handling (website AAI;2005).

Besides airport reconstructions, major developments are under way for road infrastructure. The total length of the Indian road network exceeds 3.3 million km. The final responsibility for this roads lies within the Ministry of Road Transport and Highways (MORTH) except for rural roads which are the responsibility of the Ministry of Rural Development. The roads are generally divided in national highways, state highways, major district roads and village or other roads (table 2). National Highways cover only 2 percent of the entire road network, but bear over 40 percent of India's traffic.

Classification	Total length	Managed by
National Highways	65.569 km	MORTH/NHA
State Highways	131.899 km	State government
Major District Roads	467.763 km	State government
Village and Other Roads	2.650.000 km	Municipal councils/MRD/Other

Table 2; Indian road network (Website NHA; 2005)

To maintain and develop roads, management is done by several different public authorities. Maintenance on most of the National Highways is managed by state Public Works Departments (PWD) on behalf of the MORTH. National Highways which are reconstructed or developed as a part of the National Highway Development Plan (NHDP) are managed by the National Highway Authority

of India (NHAI). State governments decide which state highways are being built or reconstructed. The works are managed by the state PWD's. Some states have created a separate entity for state highway development, like the partially private owned Tamil Nadu Road Development Company (TNRDC) Ltd. and Road Infrastructure Development Company of Rajasthan (RIDCOR). District roads and city roads are managed by the state and municipal governments respectively.

The NHDP is a daring project which has been taken up by the Government Of India (GOI) to connect the major cities of Mumbai, Delhi, Chennai, Kolkata and the major sea ports with a vast road network. It is considered to be the most important ongoing road construction project in the country. The project consist of three phases in which a 24.279 km of road is built or rebuilt into 4 or 6 laned roads. The first two phases encompass the construction of the Golden Quadrilateral (GQ) and the North South – East West Corridor (figure 3). The entire project is planned to be completed by December 2012. A status report, created 30th of June 2005, revealed that 42% of the entire project is completed. 934 km are still needed to be constructed of the GQ and 6593 km of the NS-EW Corridor.

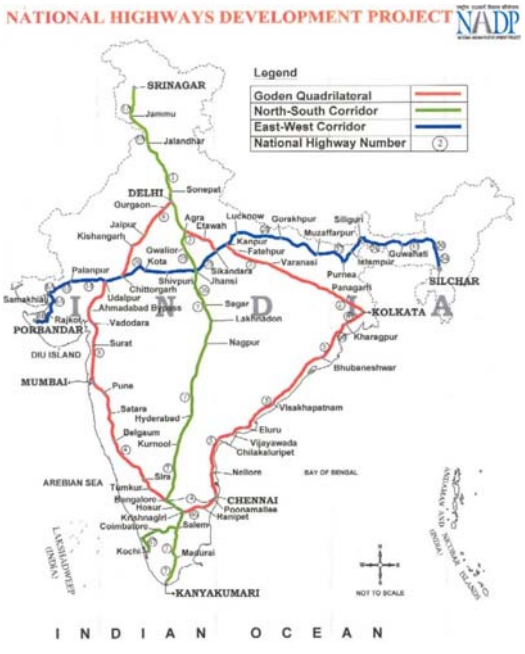


Figure 3; NHDP map (Website NHAI; 2005)

Apart from National Highways Development Projects (NHDP) there are about 41.290 km of National Highways whose development and maintenance is being carried out from the funds available from Budget. Large projects are also at hand within several states, like the Karnataka State Highways Improvement Project (KSHIP) which comprises the improvement of 2269 km. of road in the state of Karnataka only. For rural development the government has launched a scheme called the Pradhan Mantri Gram Sadak Yojana (PMGSY), to provide connectivity to unconnected rural habitations as part of a poverty reduction strategy. Within this project 380.000 km of road will be constructed and 370.000 km of road will be upgraded.

Because of the enormous size of the country, contractors usually have to mobilize their equipment over great distances and set up asphalt production plants nearby the project location. To make projects economically beneficial NH-projects generally cover stretches of 50 km or more. Within rural and urban road projects sometimes local contractors are responsible for maintenance, but large packages are also tendered to attract bigger contractors, especially with new construction of roads.

Such enormous road development is not seen anywhere in the world. These projects cause a big demand on construction resources and require a lot of funds and supervision. The latter is a key element within quality assurance.

2 Culture

From north to west and east to south, Indian people are diverse, the languages vary and customs are distinctive. In spite of India's history being influenced by partial occupations of several world powers, it has kept its own identity. This is partly because of its village orientated culture which has also resulted in the huge variety in castes, dialects, religion and eating habits. All these differences within one country has made people consider India as a subcontinent instead of a country and has made it impossible to generalize the Indian and its culture. About 70 percent of India's inhabitants live in rural areas where despite the countries modernization efforts traditional and provincial beliefs and practices have changed very little throughout the centuries.

Hindi and English are India's official languages, but 14 more are recognized by the government, like Tamil and Bengali. In the preliminary research language barriers were identified as a risk, but the case study revealed that this was not the case.

India distinguishes itself in a very colourful and religion orientated culture where 83% of the population adhere to the Hindi belief, which is a remarkable complex entity consisting out of several heterogeneous aspects like religion, economics and sociology. Other well represented religions are the Muslim, Buddhist, Christian and Sikh religion. Generally the different religions live in peace and harmony, but from time to time India is the victim of a religion related terrorist act.

The caste system, which was implemented by Brahmin priests to secure their power over 3000 years ago, is another complicated aspect of modern Indian life, although the government is making an effort of breaking the vicious circle for the lowest cast, also known as scheduled cast, to give some of them preferential treatment in government jobs and education. A scheme which is often abused by falsifying scheduled caste certificates. The cast system is seen as system which has kept a sense of order and peace among the people although others see the system as an obstacle for the country's development.

Indians tend to operate as "islands" and often perceive their own particular community as the centre of the world. They may often be parochial, which leads them to be critical and negative rather than supportive of one another. Indians have always viewed foreigners, particularly Westerners, as more superior. In India, fair skin and Aryan features are highly prized physical attributes. The public perception is that "white" skin is associated with the upper class, dark skin with the lower class (Dunung;1999).

In various literature Indian's corporate culture is described as a family culture. Trompenaars and Hampden Turner (1997) have described several aspects which are applicable to doing business within this culture and which were also recognized during the research regarding this thesis. One of these aspects is the fact that family corporate cultures give low priority to efficiency but high priority to effectiveness. Who is doing something is more important than what is being done. Indian businesses are crowded with specialists and "important people" in contrast with Dutch companies where more all-round orientated people are found. It takes a lot of time and effort to

get all specialists to agree on one subject. Although Jossey-Bass (1998) claims that western ideas are easily adopted, this research showed that a product which has proven to be successful throughout the world has to prove itself again in India to sell. Indians tend to consider their country unique and products can work out differently in India. It could even be the case that Indians tend to choose an opposite product. When Coca Cola® is the best selling cola in the world, Indians seem to drink more Pepsi® and as MSN® Hotmail is commonly the most used free web mail service, Indians seem to prefer Yahoo® mail. Introducing a new product as modified bitumen and announcing that it is the most popular product used worldwide does not guarantee sales. It would require a lot of testing in India's "specific" environment.

In construction projects there is not much affection with the constructed object, no sense of pride and duty in work, which is reflected in the quality of works. The fact that the work has been carried out is sufficient for them to state that they have fulfilled their task. An explanation can possibly be found in the fact that an Indian's job is mostly a matter of faith than a matter of choices, especially for unskilled and skilled labourers. A carpenter's son is likely to be a carpenter also. Of course India's economy also plays a key role in this matter.

Together with the country's development the sense of quality is changing. Awareness of public money spending has grown. Road owners have acknowledged that better constructed roads save money in the end due to less maintenance and user costs. Regular maintenance prevents roads from completely deteriorating and also keeps costs at a lower level. The NHDP project is not only a matter of building as much roads as possible, but also a matter of qualitative durable roads. Nevertheless Indians tend to ignore problems and will not always enlighten somebody about upcoming difficulties, probably hoping it will fade away. They tend to create a view which is more optimistic than reality, which can lead to disappointments or in problem development beyond low-cost intervention. Accountability is weak and procrastination is evident, especially in the public sector (Dunung; 1999).

Figure 4; Bahai temple, Delhi

Despite this negative view of Indian culture it has to be recognized that many achievements have been made in Indian construction (figure 4) and that may more are likely to come. Ooms' companies in India are fully operated by Indians who are known with the characteristics of there fellow countrymen. Sales managers are operating in there own environment, within or nearby there birthplace. Problems caused by culture differences are therefore minimized.

3 Politics

India inherited its political structure from the British who ruled the country for more than 100 years. The form of government is parliamentary and every state and union territory has its own government with restricted powers. The government consist of three separate branches (trias politica): The executive, the legislative and the judiciary. The executive branch is technically led by the president who is the constitutional head of the government and the vice president, both of whom are elected indirectly for five-year terms by the two national assemblies and selected state assemblies. Similar to the monarch of the United Kingdom, the president invites the leader of the majority party or coalition of parties to form a council of ministers, headed by the prime-minister, who holds the real power. India's bicameral legislature, called the Parliament, consists of the Lok Sabha (House of the People) and the Rajya Sabha (Counsil of the States), The council of ministers is technically accountable to the Lok Sabha. The normal term for the Lok Sabha is five years and the elections for the Rajya Sabha are held indirectly. The Lok Sabha is the more powerful of the houses, although both are required to consent to all legislation.

State governments are structured similar to the federal system. A governor, appointed by the president, functions as the head of state. The state council of ministers, headed by a chief minister, has the real power in each state.

India's policies are aiming at becoming a developed country within 20 years. The government recognized that India's growth is dependent on seven sectors which Prime Minister Manmohan Singh called 'Saat Sutras' in his Independence Day addresses of 2004 and 2005. These sectors are: Agriculture, irrigation, education, health, employment, urban renewal and infrastructure. About the latter sector the Prime Minister stated that it is necessary to have a strong infrastructure in order to ensure that the economic growth does not slow down. The NHDP and other projects in India show that the Government of India (GOI) is taking this matter seriously.

In recent years efforts have been made to decrease the bureaucratic processes, but companies and individuals still need a lot of signatures to get things done. And although ending corruption has also been a key element in Indian policies, National Integrity Systems conclude in its 2003 country study report that the government has not given any systematic thought to this aspect so far except for the Tenth Five Year Plan. In India incentives or bribes still help speed up bureaucratic processes as corruption is a part of Indian culture and the public has come to accept this as a normal pattern of lackadaisical approach in every walk of officials and even corporate dealings, so much that any clean and transparent dealings invokes surprises. National Integrity Systems also conclude that India is a "throbbingly alive democracy" and an open society, where the scams and incidences of the deep-rooted corruption cannot be suppressed and swept under the floor for long (Doig&McIvor;2004). Newspapers report frequently about scandals which are exposed. Websites from public institutions are very informative about how public money is being spent and provide detailed information about many tenders. Everything in India is tendered, not a rupee is spent without one.

4 Economy

The leaders that came after independence stated that economic progress for India was withheld by the British. Native companies were undercut by British companies and modern industries were not developed. The British kept their industrial knowledge for themselves and profits of exports went to Britain. As a result the new Indian government made plans to make India's economy flourish as an independent economy according to a Soviet model of self reliance. The state invested in huge companies and avoided foreign influences. Decades of market protection by import taxes and a local orientated market has made the Indian industry inefficient (Boon, 1997).

Since 1984 India opened its economy for foreign investors and import taxes were lowered. Foreign investors were reserved, because of the hindering by the Indian government in the past. Imports grew massively, but Indian companies were not ready for export. A shortage on the balance of trade and a government which spent more money than it collected, resulted in a financial crisis in 1991. Nevertheless, India managed to build a wide industrial base on its own and has a long industrial tradition in contrast to other developing countries. Unlike the Soviet Union, India has always kept a free market system. Besides the government owned companies, there were also private owned companies and a lot of Indians worked as farmers or owned a small informal company in trade or in traditional workmanship.

To cope with the crisis of 1991 the Indian government relied on the IMF and the World Bank. These institutions demanded liberalisation of the economy. This resulted in a market oriented economy with less bureaucracy and more opportunities for foreign investors. Nowadays India is the largest recipient of World Bank assistance borrowing an amount of $2.9 billion of which 52% is spent on energy and infrastructure (figure 5). Other financial institutions supporting India are the Asian Development Bank (ADB) and the Japanese Bank of International Cooperation (JBIC).

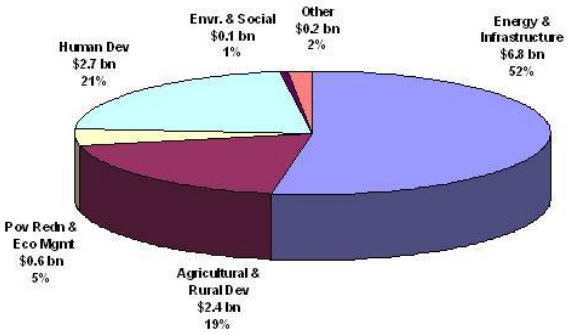


Figure 5; World Bank lending by sector (website Worldbank;2005)

Liberalisation of the economy also meant the start of the privatisation of state owned companies. The process of economy liberalisation has not yet ended, but the results are noticeable. Presently India's economy is the second largest growing economy of the world after China. The government aims to be a developing country by the year 2020. According to the World Bank, India's Gross Domestic Product (GDP) has grown 8% in 2003 to US$ 530 per capita. Nevertheless there is still a huge number of people living under the poverty line (23%) and there are huge differences between the economic powers of the different states. The 2004/2005 GDP growth has been less due to a decline in the agriculture growth because of weaker monsoon rains. 21,2 percent of India's GDP is earned within the agriculture sector. The main sector is services (51.8), which is also a booming export product. Software manufacturers are landing in cities like Hyderabad and Bangalore which

are growing immense. Indian call centres are providing services all over the world and accounting services are outsourced to Indian companies.

The massive infrastructure projects are funded with the Central Road Fund (CRF) and state taxes, external assistance, private sector participation by BOT-projects and market borrowings. Some projects are financed by a so called Special Purpose Vehicle (SPV) which actually act as an BOT operator. The total NHDP project costs are estimated on 5.40 billion Indian rupees, which is based on 1999 prices. The division of NHDP finances is given in table 3.

Total Cost	Rs.54,000 Crores	US$ 13.2 Billion
Cess on Petrol and Diesel	20,000	4.90
External assistance	20,000	4.90
Market borrowings	10,000	2.40
Private Sector Participation	4,000	1.00

Table 3; NHDP financing based on 1999 prices (Website NHA; 2005).

The Central government has created a dedicated fund, called Central Road Fund (CRF) from the collection of cess of 1 rupee per litre on petrol and diesel. The Union Budget for 1999-2000 and 2003-04 introduced an additional levy of cess of 1.5 rupee litre on high speed diesel and 1 rupee on petrol. In 2004-2005 53.6 billion rupees were distributed for development and maintenance of NH (34%), rural roads (40%), state roads other than rural roads (18%) and for provision of railway over bridges/under bridges and other safety features (8%). For state, district and rural roads, funds are also generated by state taxes. The expenditure of these funds is the responsibility of the respective state (MORTH; 2005).

The funds available within the CRF are not enough to finance all ongoing infrastructure projects in India. Therefore in 2004-2005 the GOI has found foreign assistance by lending money for national projects from the World Bank, ADB and the JBIC to the tune of US$ 1.3 billion, US$ 950 million and Yen 32 billion respectively (Website MORTH; 2005). These institutions are also funding state projects. For example: The World Bank is funding 80 percent of KSHIP which is an amount of US$ 360 million.

Private sector participation is another way of cutting back cost for the government which has started a scheme to encourage investors to participate in infrastructure projects. This scheme embraces the following initiatives:

- Declaration of the road sector as an industry;
- Provision of capital grants subsidy up to 40% of project cost to enhance viability of the projects on case-to-case basis.
- Duty-free import of certain identified high quality construction plants and equipments;
- 100% tax exemption in any consecutive 10 years out of 20 years;
- Provision of encumbrance-free site for work, i.e. the Government shall meet all expenses relating to land and other pre-construction activities;
- Foreign direct investment up to 100% in road sector;

- Easier external commercial borrowing norms;
- Higher concession period, up to 30 years;
- Right to collect and retain toll.

(Website MORTH; 2005)

A number of projects have been planned and executed on Build, Operate and Transfer (BOT) basis, like the entire NHDP phase III, which is in its preparation phase. The huge upfront capital investment and high risk of revenue collection have been recognised as potential deterrents to private sector participation. To address this, in addition to giving the incentives mentioned above, the government has also decided to offer some projects on annuity basis. The NHAI has also formed SPVs for funding road projects. These SPVs are separate legal entities formed under the Companies Act, 1956. It involves some cash support from the NHAI in the form of equity/debt; while the rest of funds come from ports/financial institutions/beneficiary organisations in the form of equity/debt. The amount spent on development of roads/highways is to be recovered through tolls within a prescribed concession period (MORTH; 2005).

Besides roads, airports are also developed on BOT basis of which the new Bangalore airport is the first of many more to come. Construction has started in July 2005 after several delays related to financial closure. The concessionaires Siemens (40%), Larssen and Toubro (17%), Zurich Airport (16%) and the national and state government (both 13%) are responsible for airport operation for 30 years.

5 Legislation

India has an independent judicial system, with the highest level being the Supreme Court. Indian law is based on government statues, customary law and case law. The legal system is well-developed in comparison with those of many other Asian countries, due in large part to the contributions by the British who developed the legal infrastructure. While India is technically a secular country, ethnic and religious differences have influenced the development of certain laws, particularly in the area of personal law which provides unique standards for different religious communities. As members of the world's largest democracy, Indians take great pride in their freedom (Dunung; 1999). Perhaps that is why people do not always comply with the law.

Legislation is strict, but there is too little control because there are not enough resources available. Low accountability and corruption within the law enforcement also reduces the chances of strict compliance.

In construction projects the same thing happens as within national legislation. There are strict guidelines and standards for executing works, but the level of control is hardly dependent on availability of resources, which in its turn is dependent on the amount of money involved. Generally external supervisors from private companies are performing better than employees of public authorities such as PWDs. Only within large projects it is affordable to work with consultancy agencies, which are responsible for supervision. Even then it is possible that supervisors hook up with contractors.

Construction contracts are generally set up by Indian contract models which are dated from the time that the British ruled over India. Obligations and rights are not always equally divided between clients and contractors. Contracts of ADB and WB sponsored projects are set up according to the Fédération Internationale des Ingénieurs des Constructions (FIDIC) model which encompasses a better division of obligations and rights of the several stakeholders which positively influences the performance of contractor and pavement owner.

BOT projects are not only a matter of generating funds for construction, but it is also expected that contractors perform better as they are responsible for their own road. Unfortunately, legislation is also falling short within these contracts. Functional specifications are not very well specified in these contracts and governmental agencies are rarely checking BOT-operators for there performance and road users continue paying, even when the road is not functioning properly.

In many worldwide construction projects it often happens that a contractor hires a subcontractor for executing a part of the works. In India it often happens that the subcontractor subcontracts the work and the next subcontractor also subcontracts. Eventually the original contractor has no idea who is doing what which negatively influences his control over the works. Presently only 40 percent of the project costs are allowed to be subcontracted.

6 Climate

The Indian Meteorological Service divides the year into four seasons:

- The dry, hot summer from March through May;
- The southwest monsoon from June through September when the predominating southwest maritime winds bring rains to most of the country;
- The northeast, or retreating, monsoon of October and November;
- The relatively dry, cool winter from December through February.

These seasons do not occur uniformly throughout South Asia. The monsoon draws over the country and does not cover the country in one time.

A variation in temperatures is also caused by the countries size and its longitudinal differences, but also by the variations in altitude caused by the various mountains and plateaus. Summer temperatures can rise above 45°C in various places. When the monsoon comes in, it does not cool down. The dusty environment is only replaced by a wet and muddy place. During this season it does not rain all day but at least once a day there are very heavy rains. The annual average rainfall is 2000 mm with extremes up to 10 meters a year in Cherrapunji which is situated in the north eastern state of Meghalaya (Singh&Finlay; 2003). Figure 6 shows maps of the annual rainfall and average temperatures in July.

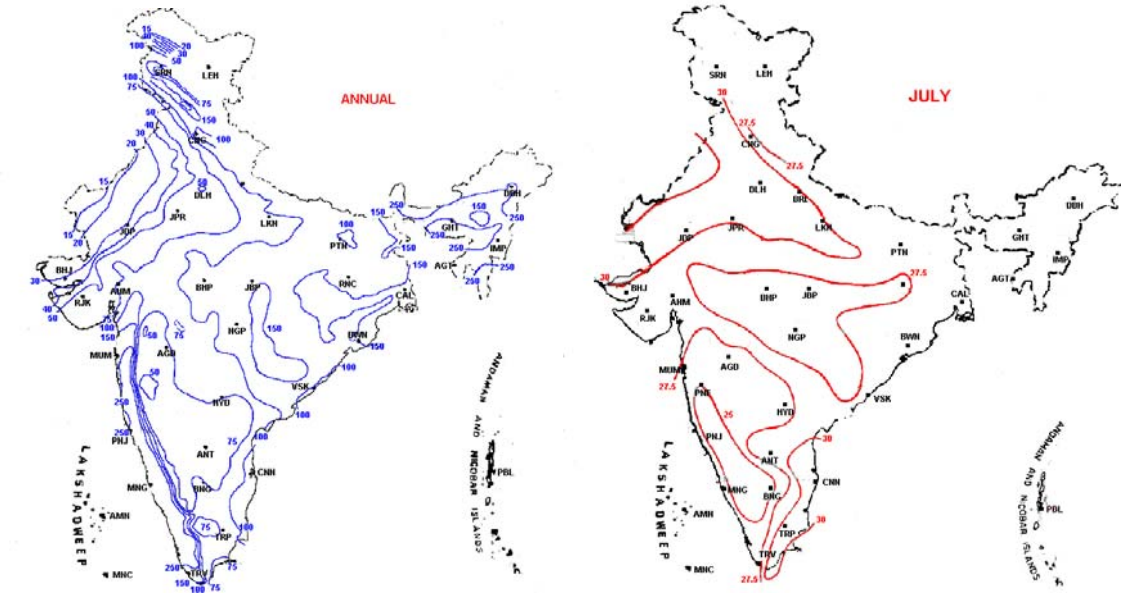


Figure 6: India's annual Rainfall and July temperatures (Website IMD; 2005)

The weather's impact on pavements and pavement construction is enormous. Rain can cause base layers to soak or particles to flush out during construction. Paving asphalt during rain can also cause the pavement to fail. Within the long list of successful Sealoflex® projects, there are only a few Dutch projects where the pavements' life span was only 10 years, which is relatively short in contrast with other Sealoflex® projects. One of these pavements was constructed during the first few years of applying Sealoflex® and showed signs of ravelling. This failure was attributed to the

fact that work could not be stopped during a heavy rainfall because the road had to be in operation the next morning (B.J.A.M. Lieshout, 1999). In India generally all work is stopped during monsoon, but sometimes rain is ignored, especially during construction of granular layers.

Even when construction is finished, heavy rains can cause base layers to soak and roads to fail, especially if drainage facilities are inadequate. Rain can also cause pavements to become slippery. 30th of July 2005 a Boeing 747 skidded off the runway in Mumbai which was terribly hit by rains that year.

Because of the hot temperatures, roads can loose their strength or bitumen starts to come out which can also lead to deterioration of the pavements and slippery surfaces. All in all, India's climate contributes to the fact that the life span of roads in India are less than in Europe. PMB offers bigger resistance against weather influences, but only when it is applied properly.

Appendix IV; List of duty free equipment

Nr.	Item
1	Hot mix plan batch type with electronic controls and bag type filter arrangements more than 120 T/hour capacity
2	Electronic paver finisher (with sensor device) for laying bituminous pavement 7m size and above
3	Slip form/fixed form paverfinisher for laying concrete pavement
4	Surface dressing equipment (self propelled) (chips spreader)
5	Slurry seal machine for filling up cracks in roads
6	Kerb laying machine
7	Mobile bridge inspection unit
8	Mechanical broom with blower
9	Toll collection and traffic control equipment
10	Electronic Total station instrument for topographic survey
11	Global positioning System (GPS) Instrument
12	Stone crushing (cone type) plants
13	Concrete Batching plants 50 cum/hr or more
14	Hydraulically operated self propelled piling rig with accessories
15	Hydraulically operated rough terrain self propelled 100 tons crane with telescope boom
16	Hydraulically operated self propelled soil boring equipment with casting pipes for deep earth anchor
17	Mobile concrete pump placer of 90/120 cu m/hr capacity
18	Automatic asphalt extraction equipment
19	Fully automatic, hydraulically operated, pre-cast segment moulds
20	Hydraulic gantry crane of 00 tonnes capacity for launching truss
21	Skid steer loaders

Source: Indian tax legislation handbook

Appendix V; Identified risks

ID				Risk	Consequence	Possible type of failure						
Level 1	Level 2	Level 3	Level 4			Cracking	Bleeding	Corrugation / Shoving of mix	Stripping	Ravelling	Potholes	Depressing
DES			01	Inadequate pavement thickness	Bearing capacity too low	X		X			X	X
DES			02	Inadequate traffic parameters	Overloading of the structure	X		X				X
DES			03	Inadequate drainage facilities	Ingress of water in base and sub base layers	X		X			X	X
DES			04	U-turn	Stress on pavements by braking traffic					X		X
DES			05	Overlaying without milling	Cracks reflect through the surface	X				X		
PRE			01	Land acquisition incomplete before project start	Lateral joints	X						
PRE			02	Unknown pipelines and utility cables	Lateral joints	X						
EXC	NAT	05	01	Sand contains organic matter	Insufficient compaction			X			X	X
EXC	GRA	03	01	Sand contains organic matter	Insufficient compaction			X			X	X
EXC	GRA	04	01	Inhomogeneous mix	Unequal compaction							X
EXC	GRA	06	01	Moisture content too high	Insufficient compaction			X			X	X
EXC	GRA	06	02	Moisture content too less	No cohesion between materials						X	X
EXC	GRA	07	01	Layers applied too thick	Insufficient compaction			X			X	X
EXC	GRA	08	01	Inadequate compaction	Insufficient compaction			X			X	X
EXC	GRA	09	01	Insufficient prime coat spraying	Particles get washed out			X			X	
EXC	GRA	10	01	Insufficient curing time	Binder cohesion is too less						X	X
EXC	BIT	01	01	Flakiness is too high	Aggregates do not hook into each other	X				X		X
EXC	BIT	01	02	Rounded aggregate	Aggregates do not hook into each other	X				X		X
EXC	BIT	02	01	Transporter selects different quarry	Aggregates are from inferior quality	X				X		X
EXC	BIT	04	01	Sand contains organic matter	Binding of materials is less				X	X		
EXC	BIT	08	01	Unheated tanker	Segregation of additives				X	X		
EXC	BIT	09	01	Unheated storage	Segregation of additives				X	X		
EXC	BIT	09	02	Overheating of bitumen	Elastic properties disappear	X				X		
EXC	BIT	09	03	Exposing bitumen to air	Oxidation of bitumen	X			X	X		

ID				Risk	Consequence	Possible type of failure						
Level 1	Level 2	Level 3	Level 4			Cracking	Bleeding	Corrugation / Shoving of mix	Stripping	Ravelling	Potholes	Depressing
EXC	BIT	10	01	Too high bitumen content	No voids in the mix		X					X
EXC	BIT	10	02	Too low bitumen content	No cohesion between materials					X	X	
EXC	BIT	10	03	Wrong grade of bitumen	To stiff or soft mix	X	X	X		X	X	X
EXC	BIT	10	04	Temperature too low	Insufficient compaction	X		X		X	X	
EXC	BIT	11	01	Surface not properly cleaned	No proper binding between layers			X			X	X
EXC	BIT	12	01	No smooth spray	No proper binding between layers			X			X	X
EXC	BIT	12	02	No smooth spray	No water-resistant layer	X				X	X	X
EXC	BIT	13	01	Not enough transport capacity	Hopper runs out of material, segregation					X		
EXC	BIT	13	02	Not enough transport capacity	Standstill in paving operation	X				X		
EXC	BIT	13	03	Temperature too low	Insufficient compaction	X		X		X		X
EXC	BIT	13	04	Careless loading of trucks	Segregation					X		
EXC	BIT	14	01	Temperature too low	Insufficient compaction	X		X		X		X
EXC	BIT	14	02	Careless unloading of trucks	Segregation					X	X	
EXC	BIT	15	01	Rolling patters not applied	Insufficient compaction	X		X		X	X	
EXC	BIT	15	02	Cold compaction rollers	Asphalt mix sticks to roller	X				X	X	
EXC	BIT	15	03	Insufficient water usage on roller	Asphalt mix sticks to roller	X				X	X	
EXC	BIT	15	04	Temperature too low	Insufficient compaction			X		X		X
EXC	BIT	15	05	Temperature too high	Insufficient compaction			X		X		X
OPE			01	Traffic mix of slow and fast traffic	Stress on pavements by braking traffic					X		X
OPE			02	Overloading	Bearing capacity too low	X	X					X
OPE			03	Clogging of drainage facilities	Ingress of water in base and sub base layers				X		X	X
OPE			04	Mechanical or chemical damage	Ingress of water in base and sub base layers				X		X	X
OPE			05	No regular maintenance of small damages	Rapid deterioration of the pavement	X				X	X	

Appendix VI; Quantification of risks

ID				Risk	Consequence	Project 1		Project 2	
Level 1	Level 2	Level 3	Level 4			Chance	Consequences	Chance	Consequences
DES			01	Inadequate pavement thickness	Bearing capacity too low	1	3	2	3
DES			02	Inadequate traffic parameters	Overloading of the structure	1	3	2	3
DES			03	Inadequate drainage facilities	Ingress of water in base and sub base layers	1	2	2	2
DES			04	U-turn	Stress on pavements by braking traffic	4	2	1	2
DES			05	Overlaying without milling	Cracks reflect through the surface	1	2	3	2
PRE			01	Land acquisition incomplete before project start	Lateral joints	2	2	1	2
PRE			02	Unknown pipelines and utility cables	Lateral joints	2	2	1	2
EXC	NAT	05	01	Sand contains organic matter	Insufficient compaction	1	4	2	4
EXC	GRA	03	01	Sand contains organic matter	Insufficient compaction	1	3	2	3
EXC	GRA	04	01	Inhomogeneous mix	Unequal compaction	1	3	3	3
EXC	GRA	06	01	Moisture content too high	Insufficient compaction	2	4	3	4
EXC	GRA	06	02	Moisture content too less	No cohesion between materials	2	2	3	2
EXC	GRA	07	01	Layers applied too thick	Insufficient compaction	1	4	2	4
EXC	GRA	08	01	Inadequate compaction	Insufficient compaction	1	4	3	4
EXC	GRA	09	01	Insufficient prime coat spraying	Particles get washed out	1	3	2	3
EXC	GRA	10	01	Insufficient curing time	Binder cohesion is too less	2	2	2	2
EXC	BIT	01	01	Flakiness is too high	Aggregates do not hook into each other	1	3	2	3
EXC	BIT	01	02	Rounded aggregate	Aggregates do not hook into each other	1	3	2	3
EXC	BIT	02	01	Transporter selects different quarry	Aggregates are from inferior quality	1	3	2	3
EXC	BIT	04	01	Sand contains organic matter	Binding of materials is less	1	2	2	2
EXC	BIT	08	01	Unheated tanker	Segregation of additives	1	3	2	3
EXC	BIT	09	01	Unheated storage	Segregation of additives	1	3	2	3
EXC	BIT	09	02	Overheating of bitumen	Elastic properties disappear	1	3	1	3
EXC	BIT	09	03	Exposing bitumen to air	Oxidation of bitumen	1	3	2	3

ID				Risk	Consequence	Project 1		Project 2	
Level 1	Level 2	Level 3	Level 4			Chance	Consequences	Chance	Consequences
EXC	BIT	10	01	Too high bitumen content	No voids in the mix	2	2	3	2
EXC	BIT	10	02	Too low bitumen content	No cohesion between materials	2	3	3	3
EXC	BIT	10	03	Wrong grade of bitumen	To stiff or soft mix	1	3	2	3
EXC	BIT	10	04	Temperature too low	Insufficient compaction	2	3	3	3
EXC	BIT	11	01	Surface not properly cleaned	No proper binding between layers	2	2	3	2
EXC	BIT	12	01	No smooth spray	No proper binding between layers	1	3	2	3
EXC	BIT	12	02	No smooth spray	No water-resistant layer	1	3	2	3
EXC	BIT	13	01	Not enough transport capacity	Hopper runs out of material, segregation	1	3	3	3
EXC	BIT	13	02	Not enough transport capacity	Standstill in paving operation	1	2	3	2
EXC	BIT	13	03	Temperature too low	Insufficient compaction	2	3	3	3
EXC	BIT	13	04	Careless loading of trucks	Segregation	1	3	1	3
EXC	BIT	14	01	Temperature too low	Insufficient compaction	2	3	3	3
EXC	BIT	14	02	Careless unloading of trucks	Segregation	1	3	1	3
EXC	BIT	15	01	Rolling patters not applied	Insufficient compaction	1	3	2	3
EXC	BIT	15	02	Cold compaction rollers	Asphalt mix sticks to roller	1	2	1	2
EXC	BIT	15	03	Insufficient water usage on roller	Asphalt mix sticks to roller	1	2	2	2
EXC	BIT	15	04	Temperature too low	Insufficient compaction	2	3	2	3
EXC	BIT	15	05	Temperature too high	Insufficient compaction	1	3	1	3
OPE			01	Traffic mix of slow and fast traffic	Stress on pavements by braking traffic	2	2	3	2
OPE			02	Overloading	Bearing capacity too low	3	2	3	2
OPE			03	Clogging of drainage facilities	Ingress of water in base and sub base layers	3	2	3	2
OPE			04	Mechanical or chemical damage	Ingress of water in base and sub base layers	3	2	3	2
OPE			05	No regular maintenance of small damages	Rapid deterioration of the pavement	2	3	3	3
Average						**1.49**	**2.72**	**2.21**	**2.72**

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LARSEN & TOUBRO LIMITED

ECC DIVISION (ENGINEERING, CONSTRUCTION & CONTRACTS)

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17/08/04

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **M/s OOMS PMB Pvt Ltd**, a wholly owned subsidiary of **OOMS AVENHORN HOLDINGS BV**, Netherland has been supplying with Polymer Modified Asphalt (PMB – 40 SBS type) for BC laying in our 42.00 Km stretch of TN 01 package (Chennai – Tada) of NHAI Project. The PMB SBS type has been produced by an automated centrally process stationery plant equipped with the testing facilities at Manali, Chennai. Laying has been executed with conventional equipments being used by us. They deployed the technical personnel from Netherland at site for providing assistance in quality control of Modified Asphalt, mix productions and pavement construction as and when required by us.

We are satisfied with the products, technology and methodology of work. We have no hesitations in recommending them for works of this nature in future.

For LARSEN & TOUBRO LIMITED
ECC DIVISION

(K. SESHA REDDY)
CONSTRUCTION MANAGER

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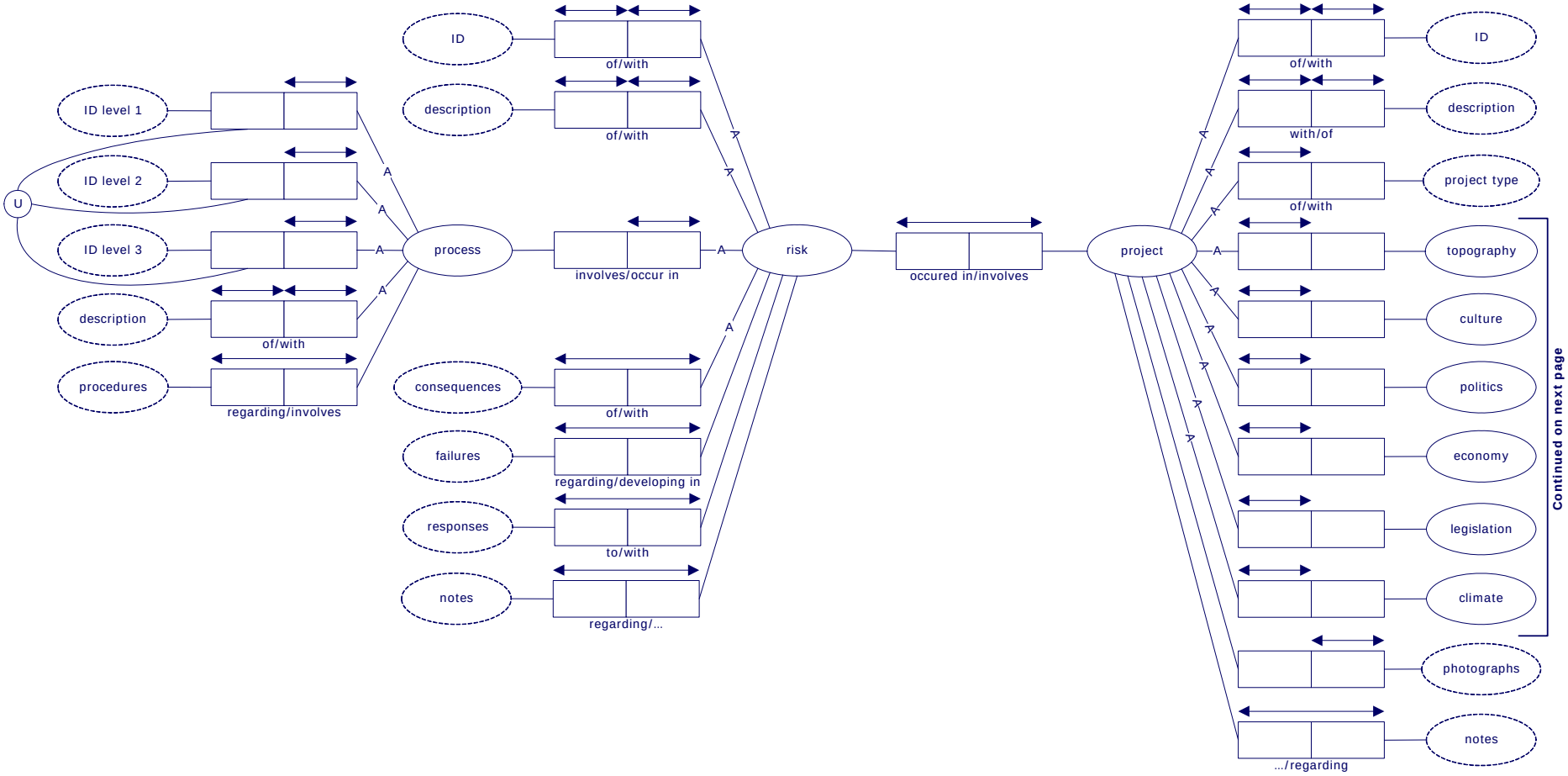
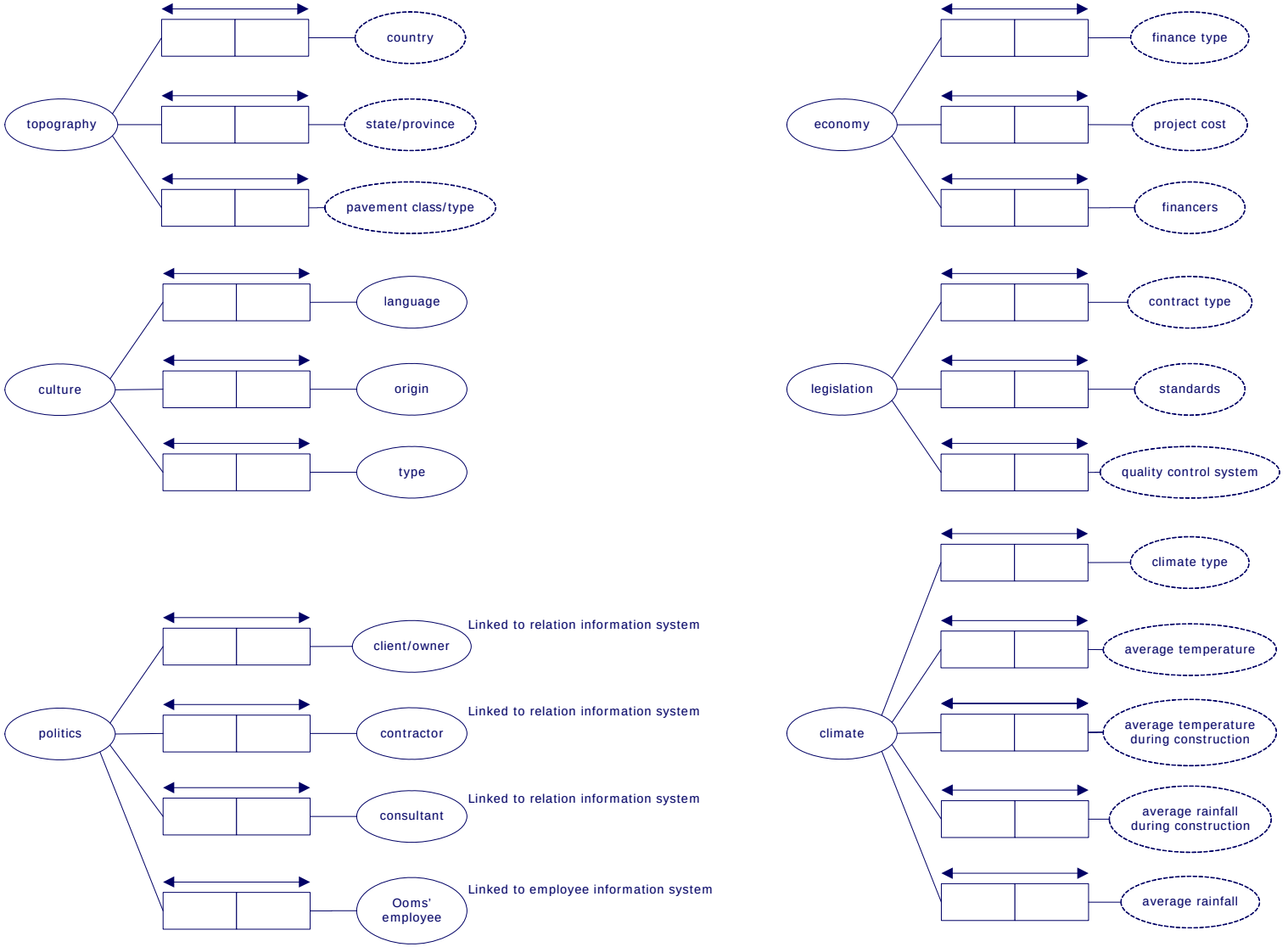
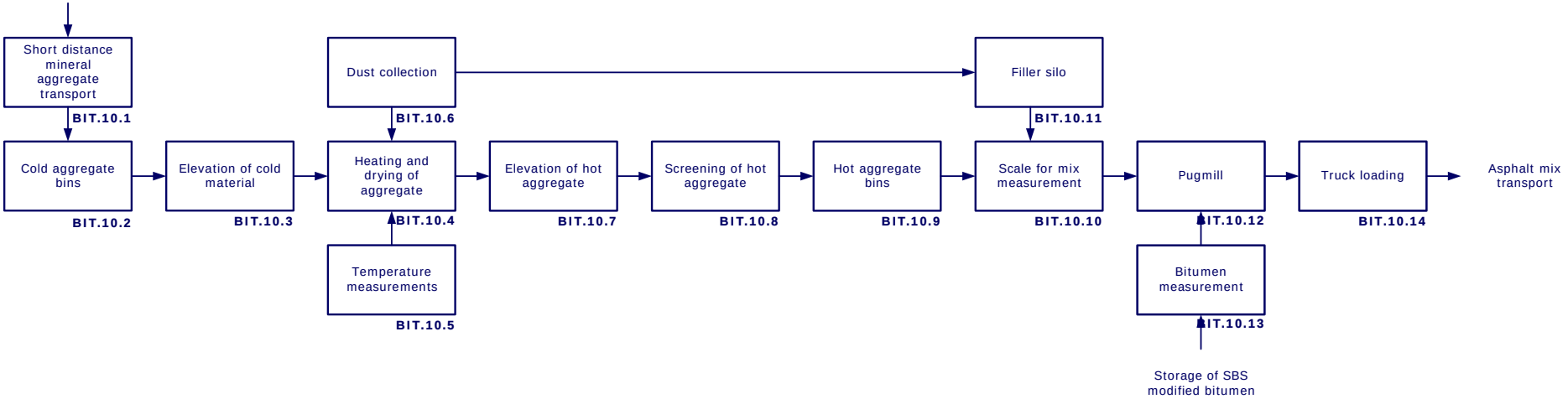
Appendix VIII; NIAM diagram of the proposed information system



Appendix VIII; NIAM diagram of the proposed information system



Batch mix plant



Drum mix plant