1 INTRODUCTION

The project “Technical Solutions for Low Cost Mountain Road Maintenance” deals with landslides, earthworks, retaining structures and erosion protection on hill roads and embraces feasibility study, investigation, design, construction, improvement and maintenance. The prime focus is on hilly and mountainous areas where budget maintenance of roads is important as it is the only means of transportation.

In mountainous regions like Himachal Pradesh, without Railways and Aerial transportation, roads are the only means of the transportation. So, it adds to the necessity of efficient and low cost maintenance of roads in hilly areas. If the roads are not well maintained there will be constraint in mobility, a significant rise in vehicle operating cost, accident rates will increase specially in the hilly and mountainous areas.

Well this answers the question – why is the road maintenance important? But this doesn’t answer why the cost should be low? Developing economy like India, government officials don’t want to spend significant fund in the road maintenance, so if there is a possibility of low cost maintenance, they will always support the ideas.

The main problem in the low cost road maintenance is that maintenance has always been considered as a third grade project. People always want to build new things, but after the things have been made, they don’t care much about the thing and the destruction starts there.

From the above paragraph it is clear that our project is important for socio-economic development of the hilly and mountainous regions. Low cost road maintenance has always been a hot topic for research from last 2-3 decades. But if we talk about low cost road maintenance in hilly regions there is not much research available.
We will work on the problems that destabilize the roads mainly in hilly regions, like soil erosion, landslides, etc. Drainage is also a big problem for road maintenance, we have to find a solution for drainage too. The target of this project is to find a feasible technical solution for the maintenance of hill roads. Towards the end of this project, our team wants to accomplish social satisfaction, by either finding a solution to road maintenance or replacing the raw material involved in construction purposes.

Our objectives towards accomplishing the goal are:

- To find the main problems in hilly roads like soil erosion, landslide, drainage, etc.
- To think, how can we stop these problems and if we can’t stop them, than how can we minimise their effect on roads.
- To think that how can we improve the existing solutions.
- To give a possible technical solution for the road problems.
2 LITERATURE REVIEW

Road maintenance had never been considered a matter of concern because of its cost and other matters of much more importance than this. This chapter deals directly with various factors such as description of influential geographic locations, involvement of backers and their affiliation to this project, synopses of exploration already done in this field, if any and lastly, illustrations of similar case studies from the world.

2.1 SITE DESCRIPTION

As the project title clearly states, the chief area of study will involve roads in mountainous regions and hilly remote locations. Considering the budget provided, locations on higher altitude with comparatively less road maintenance, closest to institute campus will be preferable. Geographically, Himachal Pradesh is surrounded by Jammu and Kashmir on the north, Punjab on the west and southwest, Haryana and Uttarakhand on the south-east and by the Tibet on the east. Visiting places like Naggar, Kangra, Mcleodganj, Dalhousie, etc. would be a good experience for this project. Also, tourist spots need to be considered as they play an important role in economic development.

2.2 STAKEHOLDERS

Following are the stakeholders of this project:

- General public staying in the vicinity of mountainous regions and remote locations. Public would be positively affected as reachability to remote locations gets better. Also, people would be less prone to road accidents and hence less casualties.
- Central Public Works Department would also be affected as it would be easier for them to maintain roads with fairly less expenditure.
• Daily travellers and people working in transport agencies would be affected the most as they are dependent on road network for their livelihood.
• We also fall in the category of stakeholders as the general public.

2.3 BACKGROUND

Road maintenance has been a hot topic under the area of research, but specifically for the hilly areas, it has not been taken into account. Global organisations like World Bank, United Nations, etc. helps developing countries to build good quality roads and maintain them. Since they provide monetary support to the countries, it is obvious that they find budgetary solutions for these matters. Analogous to the World Bank, some Non-Governmental Organisations in India are also working, but with no significant success till date.

2.4 CASE STUDIES

Many projects related to low cost road maintenance are ongoing or have been completed over the world. Some of these projects described below have been studied as cases:

2.4.1 Low-cost road development and its geological consequences (R. K. Dahal, Nepal)
Similar to Himachal Pradesh, Nepal is also situated in the heart of the Himalayas. Road planners, consultants and executors in Nepal realized the need of an integrated approach for site investigation, analysis, design and construction of mitigation structures on landslides.

2.4.2 Green Roads: Eco friendly and low maintenance rural roads through local participation (Frances Klatzel, 2006)
Prime intentions of Green Road concept are:-
- Develop rural road and trail networks that reduce transportation costs.
- Use environment-friendly road construction and maintenance techniques that protect the natural environment, its agricultural potential, and its natural resources against excessive erosion.
- Use locally available resources in terms of labour, material and finances.
- Generate short-term, off-farm employment opportunities especially for local people by using manual labour intensive road construction and maintenance techniques.

2.4.3 New Road Construction Concepts (FEHRL, Europe)

New Road Construction Concepts (NR2C) is an innovation project of FEHRL supported by the European Commission under the Sixth Framework Programme. The project provides future-oriented initiatives for the road infrastructure. This project aimed to generate future-orientated initiatives for accessibility problems and issues related to road infrastructure.

2.4.4 Road maintenance expenditure in H.P. (H.P. State Govt., 2013)

Himachal Pradesh has a large road network. There are 9 National Highways with total length of 1,208 km, 19 State Highways with total length of 1,625 km and 45 Major District Roads with total length of 1753 km. As a primary objective, Pradhan Mantri Gram Sadak Yojana (PMGSY) provided connectivity, by way of an All-weather Road (with necessary culverts and cross-drainage structures, operable throughout the year), to the eligible unconnected Habitations as per the Core Network in the rural areas with a population of 500 persons and above (Census, 2001) in plain areas.
Physical progress: Out of total 2,288 road works covering 13,147.40 km of length sanctioned, State completed 1,693 road works covering 10,098.74 km of length (76.81%) till October, 2013, as reported by the State. (Wikipedia, 2014)

Financial progress: Out of total value of projects amounting to Rs.2,754.68 crore (including State share of Rs. 15 crore), sanctioned, an amount of Rs.1,839.68 crore was released and an amount of Rs.1,763.08 crore was utilized (95.84%) by the State till October, 2013, as reported by the State. (Wikipedia, 2014)

2.5 CONCLUSION

Listing some key points here which need to be taken care of in this project:

- Awareness among people should be inculcated from time to time so that participation of people and the Public Works Department is more at all times
- People heavily dependent on roads should be conversed with to find out the actual grievances related to unmaintained roads.
- Projection of the future and importance of road maintenance should be there in the minds of people.
- Minimizing adverse effects of natural calamities towards roads is important if low cost maintenance is desired.
3 METHODOLOGY

Prime goal of our team is to provide a feasible technical solution for low cost road maintenance in hilly and mountainous regions.

Our objectives towards accomplishing the goal:

- We have to find the cause of main problems in hilly roads like soil erosion, landslide, drainage, potholes, Growth of grass and bushes at road side.
- We have to think, how can we stop these problems and if we can’t stop them, than how can we minimize their effect on roads.
- How can we improve the existing solutions?
- From the fulfilment of above three objectives we will try to give a technical solution for the road problems.

3.1 DISCOVERING THE PROBLEMS IN HILLY ROADS

Problems in the hilly roads can be well described by the officials who are in charge of the maintenance of the roads in that region. Generally, maintenance of the public roads comes under CPWD. So to fulfil our first objective we need to discuss the reasons of deterioration of the roads and roadside with the government officials of CPWD and PWD. Some of the questions that can be asked to the officials are as follows:

- What are the general types of problems that can be encountered in maintenance?
- How to detect the problems in hilly roads effectively?
- What should be the frequency of routine check-up?
3.2 **MINIMIZE EFFECTS OF THESE PROBLEMS ON ROADS**

In first objective we discovered the main problems in the road maintenance of hilly and mountainous regions. But finding problems is not sufficient, the real deal is to find the solution for the given problem. The same can be discussed with the government officials that what are their ways to solve the problem and we can do research on their ways and can find more efficient, cheap, easily available solution.

The basic questions that can be asked:

- What are the common work activities in routine maintenance of road?
- What is the budget allocated for the maintenance?
- What are the types of materials you use for the work activity?

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Figure: Gantt chart
4 ROAD MAINTENANCE SURVEY & QUESTIONNAIRE

4.1 GENERAL INFORMATION

4.1.1 Sites / villages visited
- Kamand (Distt. Mandi)
- Riyagadi (Distt. Mandi)
- Navlaya (Distt. Mandi)

4.1.2 Individuals Interviewed
- Mr. Manohar Lal (Central Public Works Department, H.P.)
- Mr. S. Kapoor (Project Manager, C.P.W.D, H.P.)
- Mr. Bharat Gupta (Gupta Contractors)

4.2 QUESTIONNAIRE AND GENERAL RESPONSE

4.2.1 What are the problems that require road maintenance?
- Formation of potholes
- Drywells & drainage problems
- Growth of vegetation at road side
- Cracks in roads
- Landslides
- Slips during rainy season
- Ditches & culverts
- Snowplowing
- Damaging of sign boards, milestones, light reflectors, etc.

4.2.2 What are the problems encountered in maintenance?
- Financial problems
- Labour problems
Negligence of maintenance officer
Less availability of raw material

4.2.3 How to detect the problem?
- Shrubs, trees and weeds
- Cracks in the road can be seen
- Major crack can lead to landslides
- Accumulation of water leading to blocked drainage system

4.2.4 What are the common work activities in routine maintenance?
- Problem detection
- Paper work for road maintenance
- Budget allocation
- Completion deadline

4.2.5 What is the average budget for road maintenance?
- On an average it requires around ₹ 1.5 lakh per km in single lane or ₹ 300 per m²
- Budget may increase or decrease according to the current road condition
- For national highways, budget is high

4.2.6 Frequency of road maintenance?
- Routine maintenance varies depending upon weather and various other factors
- Road cleaning and clearing of blocked drainage is done twice a week
- Patching of roads is generally done 4-5 times a year
- Renewal/tarring of national highway is done once in 3 years
- Renewal/tarring of state roads is done once in 5 years
- Emergency situation requires urgent attention
4.2.7 What are the type of raw material used in patching?

- Coarse aggregate
- Fine aggregate
- Sand
- Cement
- Tar
- Stone

4.2.8 Priority of work?

Firstly, Clearance of drainage is given higher priority. This is due to the water allocated, giving rise to many other problems. Secondly problems of cross drainage are solved. Then uprooting of vegetation is done. Finally, patching of potholes, etc.

4.2.9 Which road is preferred?

Cement roads cost 30 times compared to Tar roads. But Cement roads require very less maintenance. Moreover, life of cement road is more than that of tar road.

Note: Relevant pictures illustrating our visit and interactions with the society are given at the end of this document.
5 RESULTS AND DISCUSSION

5.1 RESULTS
The results of our fieldwork on places like Kamand, Kataula, Katindhi, Riyagadi, Navalaya (distt. Mandi) are presented in this chapter. Our baseline assessment is divided according to the objectives mentioned in the previous chapters. The prime objectives are discussed below:

5.1.1 Finding main problems in mountain roads
Based on our surveys on the sites mentioned above, the main causes of deterioration of mountain roads are roadside vegetation, cracks, landslides, avalanches, water logging, potholes, etc.

Cracks in roads develop due to overloading, seepage, improper or poor road surface drainage, lack of proper road maintenance, lack of proper design, adverse climatic conditions and some other factors.

Landslide is a geological phenomenon which includes a wide range of ground movements, such as rockfalls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments.

Waterlogging is caused due to inadequate capacity of drainage facilities to withstand storms and heavy rainfall.

Potholes are depressions in roadways that can range from a few inches wide and a few inches deep, to several feet wide and sometimes a foot deep. Potholes jar the tires of cars driving over them sometimes causing handling and suspension problems.
Photographs of some nearby sites (in this report) correctly describe the problems faced in hill roads.
5.1.2 Minimizing the adverse effects on roads
Narrow channels dug at the side of roads or fields, to hold or carry away water are called ditches. Ditches should be kept clean to allow water to flow freely from the roadway. From there, water should be routed away from the road rather than allowed to settle alongside into depressions where it will cause the road to weaken. Ditches also must drain water away from property that it might damage.

To curb with landslides, the most commonly used solutions are afforestation (slope plantation) and building retention walls.

Periodically uprooting or trimming the roadside vegetation will increase the life of roads.

5.1.3 Improvement of existing solution/Possible technical solution
Along the road, water logs at the place where the slope ends. This leads to uprooting of roads due to drainage system failure in flat areas. Construction of culverts along the road side or ploughing the soil along the road resolves this problem.

5.2 Discussion
The aim of our project is to maintain a good transportation facility. Thus doing this survey gave us an exposure of the actual scenario. There are some constraints in maintenance of the roads:

- **Budget constraint**: Generally budget allocated for the road maintenance is low as compared to required amount. In practice, budgets are not expressed as present values but as amounts that can be spent over a single year. An annual budget constraint would make no sense for a single road segment in isolation. The cost of a rehabilitation for a single segment would far exceed the budget for that segment in the year it occurs.
- **Material constraint**: Availability and cost of raw material depends upon the season. It also affects the budget and time required for completion of the maintenance.

- **Labour constraint**: It is not a major problem in the Himachal Pradesh. Labour is easily available in the area.

- **Time constraint**: The way in which government office works, is very pathetic. They require a very huge amount of paperwork, before the project, during the project and even after the project and that takes time. Total time wasted on the paperwork is so much that road crosses its limit to be maintained and now it’s time for the new paperwork regarding the renovation of the road.

Generally the maintenance work also depends on the type of road. Concrete roads need less frequent maintenance than bituminous roads on the expense of initial cost, as initial cost for concrete roads is more than the bituminous roads.
6 RECOMMENDATIONS AND CONCLUSIONS

6.1 RECOMMENDATIONS
This part of report presents original recommendations and suggestions purely based on analysis and surveys, that are not organized by objectives.

6.1.1 Plastic Roads
Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its non-biodegradability, it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively in the construction of roads.

A well constructed plastic road will result in the following advantages:

- Strength of the road increased
- Better resistance to water stagnation
- Increased load withstanding property
- Overall consumption of bitumen decreases
- Reduction in pores in aggregate and hence less rutting and raveling
- Better soundness property
- Maintenance cost of the road is almost nil
- The road life is substantially increased
- No leaching of plastics
- No effect of radiation like U.V.

6.1.2 Construction of ditches and culverts along the road
Advantage of culverts:

- Reliable
Less maintenance, suitable for steeper grades. More economical for higher traffic roads
Reduced road surface erosion, no dip to soften and rut
Prevent Flooding
Allow Water to Flow Unobstructed
Divert Water for Farming/Engineering Purposes

6.1.3 Weather dependent maintenance

6.1.4 Modified procedure of periodic road maintenance
Small decisions regarding budget allocation for maintenance should be divided in smaller authorities so as to make it robust and efficient. However, this is prone to more corruption among government officials.

6.2 Conclusion

Roads are of vital importance in order to make a nation grow and develop. Especially in the third world, good maintained roads also enhance poverty reduction by improving access between regional and rural communities and, ultimately, enhancing socio-economic growth and development. Road networks form vital links between production centres and markets. In addition its multiple function of providing access to employment, social, health and education services makes road network crucial in fighting against poverty by opening up more areas and stimulating economic and social development.

Yet even small budgets for maintenance make a difference with proper planning and right priorities. The situation in many countries concerning the road condition is not only urgent, but critical. It is important to know the costs involved in road maintenance and the costs of not maintaining the roads. The money which is saved in the maintenance budget by not maintaining the roads, is ultimately paid by the users and the society. This may be called the invisible tax, and the total cost to the economy is huge.
7 REFERENCES AND CITATIONS

Case studies and geographical data has been taken from:

- www.vetiver.org/ICV3-Proceedings/
- www.hils.org.np/ranjan/
- www.ccsenet.org/journal
- ec.europa.eu/transport/road_safety
- en.wikipedia.org

Note: This report builds on the previous report. As everything required had been added already, it is almost similar to it's previous version.

8 PHOTOGRAPHS

Road near Kamand village severely damaged due to water logging
Patch work done near Riyagadi under routine maintenance procedure

Riyagadi – Mandi road made from plastic, low cost and less maintenance
Cement concrete road – costly, less water sensitive, maintenance required

Potholes and vegetation near a Major District Road in Mandi
Landslide uprooting a steep hillside road in Mandi district