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Low-Cost Road Construction and Rehabilitation in Unstable Mountain Areas

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Abstract: ***The mountain roads are impacted by social, environmental and economic challenges. The financial management around the road construction and rehabilitation requires fine management and administrative skills to be done effectively by the local and the federal authorities. The objective of this study is to understand the factors affecting the low-cost road construction and rehabilitation in the unstable mountain areas and to analyze the solutions to the specific barriers. The materials and methods used here is a best evidence review focusing on the existing literature that emphasizes on the above-mentioned research problem. Global evidence has been used in order to draw a greater idea and explanation about the research topic. The results focus on the importance of technology leadership, financial management, risk control and mitigation, sociocultural benefits and socioeconomic scalability of the low-cost road construction and rehabilitation projects. The workforce management and stakeholder relations are very important as well for the effective running of the construction projects without any interference. The partnerships between the public and the private organizations is very much vital for ethical and regulatory compliances which is one of the major findings of the study. The sociocultural impact and the road traffic safety considerations are to be assessed properly in order to prevent and mitigate any project risk which is also a very important finding.***

I. INTRODUCTION

Road construction is one of the most important components of transportation planning within a region or different regions of the country and this must be met with various needs. Good transportation is not only important for better connectivity from different residential areas and business locations, but it also serves as the critical core to formation of social networks and communication channels[1-2]. The safety requirements around road construction and the various types of the technical aspects of the construction process is mainly dependent upon the technical aspects, the financial budgets allowed for the construction project and route details[9,10]. The route can be taken by people of certain community and social groups using a certain type of transportation vehicle and this must be taken into the consideration while constructing the roads[2,7]. It is to be noted that the economic condition of the country is weak at the present and the economic constraints often makes way for the road constructions that is low cost in nature only.

The gaps and the conflicts are important to be taken into consideration in order to understand the overall problem with low-cost road rehabilitation and construction better. Other than the economic barriers, there are certain number of other barriers such as the topographical barriers like in the mountain and other areas with irregular terrain; climatic changes and socio-technological changes over a period of time – that are to be analysed[12]. It is to be very closely noted that there can be a number of existing roads in the country or a specific region. And due to the increasing number of transportation vehicles, increasing amount of traffic and climatic adversities – a need for restoration can be developed [4,12]. This is also known as the process of road rehabilitation and sometimes 'upgradation' as well which is done to meet the modern-day transportation needs of the country. Sometimes, there will be roads that has been left unused over a period of time and instead of constructing new roads that is subjected to higher costs, a low-cost road rehabilitation process can be undertaken[1,4,9]. The low-cost road construction requires effective capital budgeting, resource management, material management and technical skills development in the new staffs involved in road construction and rehabilitation. The calibration and the recalibration of the traffic demands as per the social and business needs of the modern-day circumstances is critical and this is at the center of low-cost of construction and rehabilitation[12]. The lack of administrative management and scientific management in all of these above-mentioned areas can compromise the safety requirements of the roads being constructed and rehabilitated. The concreteness of the roads can be compromised badly, and this can lead to increased cases of accidents and other presentation of adverse situations. In the mountain areas, there can be issues of landslides, leaching related landslides and glacier breakdown leading to deterioration of the quality and safety of the roads within a very short period of time[11]. That is why, these are also the problem areas that is to be considered in unstable mountain areas.

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The trends and the new perspectives incudes data driven investment related decision making, economic appraisals, evidence-based cost accounting and conflict management practices along with technology leadership.

In this paper, a number of scholarly scientific articles has been reviewed in order to understand the major areas of the research problem and the various step wise solutions provided for the same. The different areas of low-cost road construction and rehabilitation has been explored by reviewing of the existing scientific literature from across the globe. The literature provides not only rich evidence on the chosen topic and but also on the implications that relate to economical construction management and robust policy making.

II. REVIEW

A. *The Socio-Environmental Impact of Road Construction Projects*

Siddaraju (2014) studies about the usage of reclaimed materials in the construction of rural roads that have low volume traffic generally. The researcher of this study focusses upon the importance of social, educational and the economical development of the villages who are dependent on road's accessibility to nearby urban or semi urban localities. The study uses quantitative methodology to analyze the research problem and finds out that the waste management, right combined usage of the new road construction materials and the reclaimed materials is important[1]. The calculation of the Reclaimed asphalt pavement (RAP) and other aggregate proportions plus the binder demand determinations is highly dependent on the transportation needs of the village residents. Other than these, it is also very much important that the utility values, the selection of the right villages for the road construction project, the economic analysis are all done properly for effective low-cost road construction and rehabilitation. Upgradation to all weather roads and using reclaimed materials has been found to be economically and socially beneficial for resident village people. Papayianni and Anastasiou (2012) argues in favor of concrete road pavement construction that is low cost in nature. This study focusses on the topographical conditions of Greece where there are many areas of high inclination. It is in these areas that the trucks carry heavy materials. That is why, the usage of concrete road pavement in these places of the country offer many benefits that includes allowing extra load absorption of the heavy weight carrying trucks and withstanding adverse climatic conditions. They also help to reduce the rolling resistance of the heavy vehicles thus adding to the safety considerations and longevity of the routes[2]. According to the researchers of the study, the use of the steel slag, hydraulic binder plus fly ash as the aggregates are most vital for the cost containment and safety enhancement at the same time. In an interesting article based on emergency road rehabilitation surrounding the Blake Fire incident, Smith and Wright (1987) argues for the usage and application of different rehabilitation measures for road construction and re-construction. The landslides, unstable drainages, inner gorges breakdown incidents were the main reasons behind the causation of the Blake fire incident that had a massive impact upon the killing and destruction of the local lifeforms like the trees and the downstream fisheries. The fire incident in the unstable mountain areas had a major economic and social impact on the local Californian communities as well and that is why, as a part of emergency restoration project, the rehabilitation process was undertaken. The big trees that are dead and 'high risk' in nature were immediately removed from the scenario and the channels were reconnected by removal of already dead logs. The sediment and the organic debris were retained by wedging the strawberry bales behind what is known as the replacement logs. The impact of the fire incident was both short term and long term, the effect of the adverse climate conditions like the extreme winter in this part of the world, was also a problem. The mass wasting calculations along with the watershed control are amongst the most important rehabilitation measures to be undertaken in the unstable mountain areas and roads, to prevent and mitigate the risks of fire and landslide incidents[4]. Other rehabilitation measures include the setting up of risk monitoring system, recruitment of right workforce including hand crews and earth scientists plus effective time management. According to Price, Jansky and Iatsenia (2004), a number of complex challenges in the unstable mountain areas with respect to extreme climate, global climatic shifts, desertification, hazards and the destruction of natural and water resources has to be emphasized. The communications and the access are the major problems faced by the people living in these areas and that is why, both economic and also the very legal sustainability measures have to be undertaken. For the betterment of social, educational and the economic prosperity of the mountain residents, the new technologies such as air transportation, suspension bridges and the ropeways has become a trend[12]. The road transportation must come with the advantages of shared benefits and shared experiences for people living in the mountains and that is why, cost planning, public-private partnerships and credit schemes are important measures. Intensive road construction for better telephonic and electricity services is important. According to an article by Rahman (2012), the risk control measures include strategic social and environmental management that acts against problems like conflicts, discrimination, illegal immigration, industrialization and cultural mismanagement[13].

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Oad, Kajewski and Kumar (2020) focusses on the importance of having innovation in the road construction industry that reduce overall costs and improve sociocultural prosperity. The innovations are material recycling, solar powered roads and eco-friendly roads[7]. According to the KNP roads construction manual (2020), there are a number of risk control and prevention measures that is required. These are needs analysis, environmental and road layout analysis, categorization of roads and risk monitoring, store water and storm water management systems plus decommissioning policies[20].

B. Risks Associated With Road Construction Projects

According to Ferguson (2012), there are a number of factors affecting the cost effectiveness of the road construction projects and economic value of the project has an impact on the lives of the social communities, residing locally. The coordination between the contractors and the project owners as well as the general opinion and perception of the public - play as very critical role in the development and regulation of the road construction project. There are two sides to the problems in relation to the road construction that are explored and explained in this research study. The lack of proper cost containment practices and social cost management not only leads to the traffic congestion and traffic delays but also major financial and customer base losses over a period of time[6]. The road construction is conjoined with the problems of vibration, dust, land, water, air and sound pollution. And that is why, according to the researchers the road construction project should be complying with Environmental Protection Agency policies, most imperatively. The biological problems can also result from the mismanaged road construction project that includes respiratory and neurological problems among people in local communities[6]. Improving upon the response of the local community people is important and social risk mitigation is as important as the financial management, according to the researchers of the study. The public relations team should be active and purposeful in maintaining a positive relation with the local people and they should be motivated for a more positive response. Usage of trenchless technologies, managing the flow of project life cycle and also managing the social costs are amongst the best interventions for low-cost road construction[6]. Mobility, public services, access and maintenance of safe psychosocial, physical and visual environments are amongst the most critical areas of cost-effective road construction project management. The plastic pollution is the major focus of study by Heriawan (2020). This research focusses to understand the impact of pollution caused by the overproduction of plastic waste by the road construction projects undertaken in India. According to the researcher, the rural roads in the country are impacted by extreme climatic conditions and this impacts upon the accessibility of the village people to the educational and health care centers[5]. The Asian development bank is working along with the National Rural Infrastructure Development Agency to restore and construct new and functional roads in these unstable and economically poor areas. There are the four cardinal areas where the importance has been given for low-cost road construction and these are restricted specifications (valuing engineering and construction methods), technology readiness, availability of good quality materials and cost containment[5]. The correct use of technologies and additives in bituminous and cementitious materials, secondary and waste aggregates, slope and soil stabilization technologies are very cardinal to the process of lost cost road construction. The upcycling of the plastic can be done by mixing it effectively with asphalt and by using it effectively in the building of the concrete block pavements. This effective plastic waste management will reduce pollution and better the community life as well. The minimized plastic waste has been found to increase the long-term serviceability of the roads and less than 25 percent repairs were just needed in five years. According to Kotlyakov, Osipova and Tsvetkov (2017), the instability of the mountain areas is characterized by the unstable nature of the glacier flow in the mountains. The improper glacier surges and the glacier slides poses a great deal of threat to the public transportation in the roads and serious dangers to tourists and local communities alike [11]. The use of technology such as continuous computer monitoring and aero - topographic monitoring is absolutely important to understand and assess the extent of tectonic and structural geometric changes. The studying of micro-surges also becomes more proper with the technology leadership that impacts the road construction process in safe manner, as implied. It is also implied that the remote sensors should be incorporated in the transportation systems and connectivity channels to prevent the risk at its earliest. According to Hart, Hearn & Chant (2001), the collaboration between the fields of geology and engineering is needed. The use of technology like the mapping applications and the cost calculations for the drainage, slope protection, slope stabilization and bench reinstatement activities are very important to reduce risks[16]. Hearn, Howell and Hunt (2020) believed and provided evidence in favor of slope stabilization trials as a risk control measure. The slope failures should be assessed properly, and the reinstatement works after the landslides should be undertaken by private-public partnerships. The bioengineering and safety tests are critical[18]. Keller et al. (2011), the rehabilitation of the forest roads depends on the stabilization and vice versa. Regular maintenance and checking for the asphalt distress are very critical to improve upon the risk and safety outcomes. Trenchless technology is vital too[19].

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C. Vitality of Financial Management

Tomek and Vitásek (2016) argues and puts the evidence in favor of requirements for economic effectiveness while undertaking the major highway construction projects. According to the researchers of the study, the process of economic appraisals and the investment related decision making has to be supported by the agendas, policies and safety priorities that is vital to note. The road construction and its economic effectiveness can be determined by effectiveness of the transportation system and its environmental plus social impacts[8]. The financial calculations such as the Benefit-to-cost ratio, net present value and internal rate of return has to be determined in order to understand the economic viability and sustainability of the road construction project. Life cycle cost analysis is also very important. Turochy, Hoel and Doty (2001) focusses to study the cost estimating methods and finds out its importance in the undertaking of highway construction works. The construction costs, right-of-way costs, utilities and preliminary engineering costs are to be calculated rightly in order to improve upon the financial outcomes of the construction project[3]. The economic changes like the problems related to inflation, contingencies, scope alterations, delays in the schedules and the cost overruns should also be effectively accounted for. The construction planning and the contingency planning are among the most important risk prevention strategies with respect to road construction in unstable mountain areas. The state-by-state comparison of prices, costs and transportation planning is also very critical to the road construction process. This overall will help in the financial management, better. According to Collier, Kirchberger and Söderbom (2015), it is very important that the infrastructural costs of the road construction project is assessed beforehand to prevent any project risks and complications. In the low and middle economy countries, according to the researchers, the need for the cost containment is necessary and the unit costs dispersion, residual unit costs and environment driven costs are to be accounted for properly in order to avoid any miscalculations[9]. The administrative infrastructure of the countries, the nature of conflicts, corruptions and the ability for public investments for such large-scale road construction projects are often amongst the serious problems. The demographic data, population densities as well as the difference between estimated and actual costs are to be analyzed properly for better project management. The country-time effect calculation is also recommended. Ketema, Quezon and Kebede (2016) believed that cost benefit analysis is one of the pivotal tools for financial calculations with respect to the road construction. It was found the material management, design maintenance costs and rehabilitation costs combinedly lead to more costs and expenditure in case of flexible pavements rather than in the case of rigid pavements. 7.9 million ETB was the total cost savings for the latter[10]. With time, the costs of maintenance were found to be increased. According to an article by Asian development Bank (2014), the importance of procurement, consultant recruitment, disbursements, project cost and schedules must be analyzed effectively. Passenger time costs and time savings should also be calculated for road constructions[14]. According to a report by Shreevardhan et al. (2014), the formation of green roads can be very cost effective and the stakeholder collaboration between the executors, consultants and road planners is vital. The problems of landslides and water logging will be solved[15]. According to the guide by USDA Forest Service (2020), the application of cost estimating methods like adjustment factors analysis, base rate analysis, equivalent volume calculations, stem pacing calculations and cost per mile calculations are important[17].

III. CONCLUSION

Thus, it can be concluded saying that in a way, thus the quality of the road affects the quality of lives of the people living in remote mountain areas. The sustainability in terms of waste and pollution reduction, recyclability maximization, energy and water efficiency maximization, usage of natural resources, material management and social progress of local communities has been emphasized in the articles. The lack of stakeholder management and coordination can lead to serious issues in road construction and rehabilitation. The major problem stems from the fact that the negative social effect of the project and social cost is always and mostly weighing upon the local communities and the construction companies do not take responsibility of it. This is ethically a wrong business practice as mostly all the companies and business owners have a serious corporate social responsibility to fulfil which has been implicated all throughout the studies. The collaboration between the government and the private organization is critical. This is important for the better progress of the road construction and rehabilitation projects in the mountain areas where the climatic conditions and terrain is unstable, posing varied amount of danger to people and vehicles. The different types of pollution problems associated with road construction should be controlled effectively and the policies of environmental protection should be complied with, urgently and pertinently. The financial management is one of the most cardinal areas of the cost containment in the road construction and road rehabilitation process. Financial tools like cost benefit analysis, risk safety analysis, unit costs, the macroeconomic and microeconomic analysis, cost per mile calculations and others are important. Moreover, waste management, technology leadership and also the sustainability practices are extremely critical in the planning and maintenance of the roads. The social and environmental management is also very important in the road rehabilitation practices.

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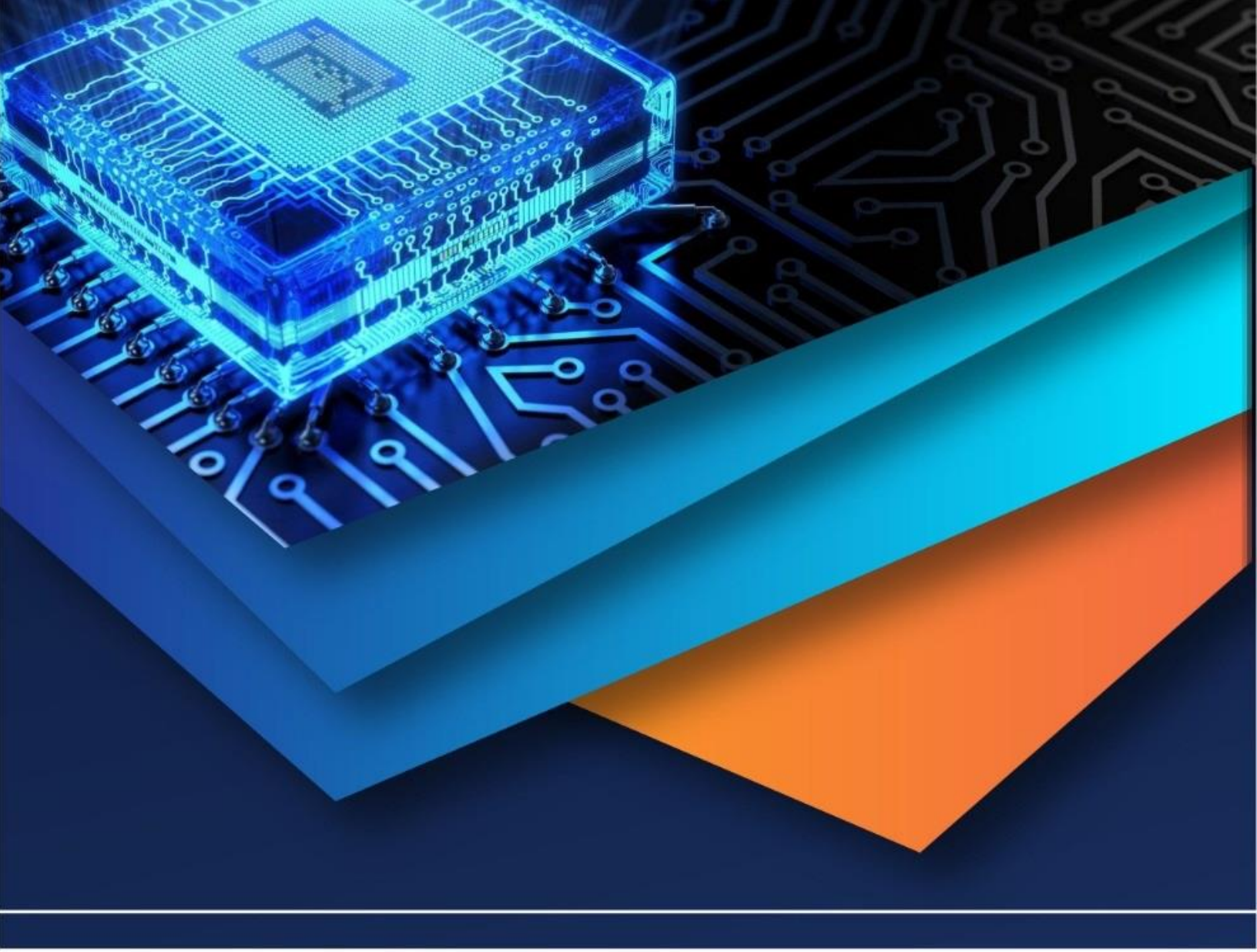

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