Status of Construction Safety in Local Road Bridge Construction and its Consequences in Project Implementation: A Study in Gandaki Province, Nepal

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Abstract

After federalization of Nepal, bridge construction in local roads by provincial levels is in increasing trend. Being highly technical and of risky nature, construction safety needs to be ensured in bridge construction. However, in countries like Nepal, safety issues are considered, with follow up measures, only after the accidents occur at construction sites. In this context, this study aims to assess the present status and consequences of construction safety in local roads bridge project implementation and explore some improvements measures. A quantitative descriptive design was adopted for the study and 30 completed bridge samples from Gandaki province were selected using convenience sampling. Data were collected using questionnaire survey with 56 participants directly related to bridge construction and policy implementation. This study revealed that most of the bridge construction sites have poor workplace safety and worker's welfare, inadequate provision and use of PPE, lack of trainings and awareness to workers as well as the absence of safety plans and method statements. Similarly, provisions for unsafe supports, shoring, formworks, concreting, and demolition were not noticed. While the absence of safety supervisor, job safety analysis, recording and reporting accident and diseases was observed, abundant cases were found where less importance was given to construction safety and use of PPE undermining the engineering and administrative hazard control methods in road bridge construction. Slip/trip/low falls, hand/leg/head injury, falling from height, eye problem, injury during erections, vehicle and electric current, cost and time overrun, substandard quality, reduced workers' productivity, increased workers turnover, low construction safety reputation of contractor, loss/damage of land, irrigation canal, drinking water scheme, dust/noise have been found as consequences of poor safety practices. This clearly indicates that present bridge construction safety practices are inadequate and need substantial improvements for better project implementation. The major areas of improvements include safety as first priority, willingness, awareness and commitment of management, contractor and worker, selection of competent workers, formulation of specific safety rules, regulations, codes and their strict enforcement, good communication, safety training and inspection, motivation, adequate budget provision in contract for safety, provision of PPE, feeling safety as self-responsibility and use of technologies as well.

Keywords: *Bridge construction, construction safety status, project implementation, Consequences, Nepal*

Introduction

Physical infrastructure refers to the basic physical structures required for an economy to function and survive, such as transportation networks, a power grid and sewerage and waste disposal systems (Das, 2017) . Construction industry is one of the largest and most important industries in Nepal. Construction safety in the industry still suffers from ignorance and lack of supervision and accident rate on construction projects is very high (Koirala, 2018). In Nepal, several motorable bridges are being constructed in order to provide improved access to service and facilities to the citizens. After federalization, local road bridge projects are being transferred from federal level to Province for implementation in Nepal. The demand for motorable Road Bridge is in increasing trend. The sustainability of any construction project depends upon the effective implementation of construction management. Also, safety is a vital part of finishing the project on or under budget. Focusing on safety helps to keep the project costs low (Ambegaonkar, 2020). Safety is the absence of danger, a state of protection and a condition involving no risk (St. and Holt, 2005).

Safety issues are being considered only after the accidents at construction site with follow up measures in countries like Nepal. Occupational safety and health related deaths account for around 2.7 million deaths around the world annually, according to the International Labour Organization. Similarly, nearly 317 million workers suffer from work-related injuries every year. There is no data on workplace-related deaths and accidents in Nepal, where safety of construction and factory workers

are taken for granted (The Kathmandu Post, 2019). It is obvious that unsafe construction will result in poor construction quality and safer construction will result in good quality standard.

So, it seems necessary to research about the state of construction safety in local road Bridge construction and its impact in project implementation. The objective of this research is to access the present status and consequences of construction safety in bridge construction project implementation in local roads of Nepal and suggesting for improvements. The results generated from this research will support Government, policy makers and different stakeholders involved in Bridge project for safe implementation by formulating bridge specific construction safety codes, guidelines and regulations and their strict implementation.

Literature review

Bridge construction project implementation is the part of transport infrastructure development. Implementation phase is the phase where the project is implemented as per design (Nagarajan, 2005). Construction safety is a factor that is required by law and enshrined in Health and Safety at Work Act (Lester, 1982).Out of 145 numbers of bridges 80 numbers are completed and 65 are under construction in Gandaki Province, Nepal. Still 113 number of bridges are in long demand list which need to be studied and go for DPR if seems feasible (MoPID, 2021). The provisions of safety for construction industries are set to minimize and eliminate injuries, to reduce property loss/damage, to minimize and eliminate deaths, to increase workers' productivity, to reduce financial loss, improved construction quality, increase company reputation Legal obligation: There are legal obligations too for understanding proper safety measures at workplace (Shrestha, 2012). The lack of a positive safety culture can result in serious harm to works and employees (Ross Technology, 2021). Those harms are increased injuries, reduced construction quality/damaged products, increased deaths, decreased company reputation, increased financial costs, legal issues, increased property damage/loss , increase in worker turnover, reduced workers' productivity.

In general, there are two major cause accidents in construction (Shreshta, 2012). Primary cause includes unsafe acts and unsafe conditions. Examples of unsafe acts are: working without authority and being at unauthorized place; fail to warn safety to others, bad loading of vehicles, failure to use PPE unauthorized service and maintenance, horseplay, smoking, drinking, taking drugs in site etc. Example of unsafe conditions are: inadequate guard to moving machine parts, defective tools and equipment, poor fire warning, poor housekeeping, poor lightening and hazardous atmospheric conditions etc. Secondary causes include failure of management system to anticipate, lack of training, maintenance, adequate job planning and instructions, not have safe system of work in workplace. Causes of accident in the construction can also be classified as: Physical (related to physical environment like wear tear of machine, explosive, chemicals etc.), physiological (related to human anatomy/factors and beyond human control like poor eye sight, health etc.), psychological (human factors like mental tension, emotional attitude etc. and biological causes (associated with poisonous plants, animal bites, insects, bacteria etc.)

The causes can also be classified as software causes and hardware causes. Software causes include knowledge based causes: inadequate safety management plan and program, lack of proper safety management plan, lack of training, lack of signage and signals at construction site, negligence and errors and mistakes because of inadequate information and knowledge, monotony, and lust for more delivery. Hardware causes are divided into physical and physiological causes. These are related with man, material, machines and tools. Falling from height, hit by falling object/s (e.g. by tools, materials, pieces of scaffolding, or other supplies), slips, trips and low falls, electrocutions, machinery accidents, crush injuries, blasting accident, vehicle accident and drowning accidents are the major accidents at construction site (Shreshta, 2012). Heinrich's principle postulates that the effectiveness of preventive and control measures decreases from top to bottom in pyramid as per figure 1 (Marshall, et Al., 2018).

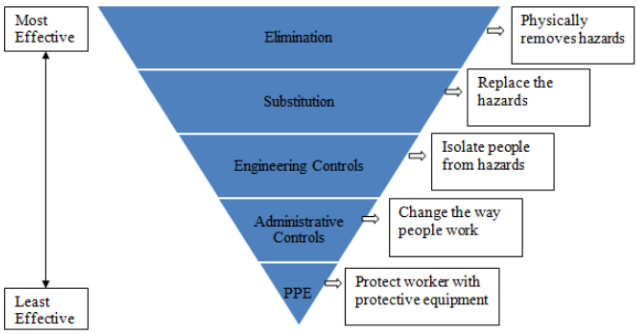

Figure 1: Heinrich's hierarchy of preventive & Control measure (Source: U.S. National Institute for Occupational Safety& Health, 2014.)

In Nepal, NBC and Labor Act are the pioneer legislations that focus on construction safety in construction projects. After being ILO member in 1996, Nepal is gradually taking pace in safe work place. NBC 114: Construction Safety provides following provisions in this standard are the minimum requirements that are to be adopted during building and other civil construction or demolition work (DUDBC, 1994).Under material handling, storage piles higher than one meter shall be stepped properly with one meter wide clear passage. Separate storage for chemicals, reinforcements shall be provided. Store near public place shall be well fenced with warning signs and clear pass way. All flammable liquids like petrol, thinners, explosives such as detonators, gun powder, gelatins, etc. shall be stored and handled confirming relevant regulations. There shall be first aid facility at all construction sites along with medical person. Adequate firefighting equipment, extinguisher shall be provided on building construction and demolition sites. For site preparation, hard hat at falling objects, safety goggles and mask in dusty areas, safety belt to work above six meter height shall be provided to workers. Areas where piercing objects or heavy falling objects may encounter, safety boots shall be provided. During earthwork in excavation, adequate measures shall be taken to protect services lines during excavation. Adequate barriers and physical guards shall be provided around excavations. No loose materials shall be left in the cut slope. Method of construction of a foundation shall be so as to minimize safety hazards. For mechanical foundation construction activities such as piling, reinforcing the adjoining properties shall be undertaken with adequate measures like shoring. While works are undertaken in deep excavations, adequate measures shall be taken against collapse of the walls of the excavation (e.g. shoring). While constructing walls, materials shall be lifted and handled carefully so as to prevent accidents. Working platforms shall be designed adequately. Walking on top of a freshly-laid wall shall be prohibited. During roof construction, no walking over reinforcement shall walking platform shall be provided. Railing or other protective guarding shall be provided on all roof edges to prevent workmen falling. Workers undertaking the mixing, lifting, transporting, laying and compacting of cement concrete shall be provided with safety boots and protective gloves. Exposed high or low tension lines, all cables shall be well insulated avoiding possible electrocution of workers and works shall be carried out by trained person using PPE for the electrical works. Temporary works shall be designed to take at least one and half times their expected load. Formwork, false work, shoring, temporary crossings shall be designed and constructed taking into account of load, stability and strength. There shall be demolition plan and provision of posters, warning signs/signals at demolition site. Materials shall not be directly dropped to ground. Safety helmets (hard hats), goggles, gloves safety boots and belt shall be provided to the workmen on the site. As far as possible use of explosives shall be prohibited and shall be done following all safety regulations by trained persons. For labour welfare, there shall be provided drinking water, sanitation, and shelter at all construction site. Adequate provision of personal protective equipment, insurance for workers, plant equipment and works as provisioned in contract document.

There is a provision of safety in Contract Document as found in different clauses. Clause 19 of GCC-Insurance: The contractor shall provide insurance in the joint name of employer and contractor for following events due to contractor's risk (PPMO, 2017): loss of or damage to the Works, Plant, and Materials, equipment, property, personal injury and death. Clause 21 of GCC- Contractor to construct the works. Clause 24 of GCC- Safety, Security and Protection of the Environment. Clause

91 of GCC- Safe traffic diversion with proper warning signs. All the construction safety procedures for bridge construction are listed in standard specifications for road and bridge construction.

In 1992, ILO published a code of practice named "Safety and Health in Construction" recommending for the use both in public and the private sectors, who have responsibility for safety and health in construction with following provisions (ILO, 1992). For safety at workplace, proper housekeeping shall be established and implemented. (Proper/separate storage of materials, removal of waste/scrap/debris, barriers/fencing to protect from falls). Unauthorized entry shall be restricted and shall be enough provision of PPE. Safety of construction tools, equipment, machines and plants shall be tested and maintained in good order and fire extinguisher shall be at right place. For safe access to elevated working places, suitable ladders shall be provided with proper design and inspection of stability. All scaffolds should be designed for maximum load with a safety factor of 4. Lifting appliance, gear, including their constituent elements, attachments, anchorages and supports, shall be of good material, design having proper installation. Lifting ropes with a known and adequate safe working capacity should be used. Drivers and operators should be trained and tested by national laws or regulations. Vehicles for earth moving shall be of good design, well maintained and operated. Elevated workplaces, including roofs more than 2 m or as prescribed, above the floor or ground should be protected on all open sides by guard-rails and toe boards .Safety harnesses should be provided and used where surrounding protection is not possible. Workers shall be physically and psychologically fit. Proper scaffolding, formwork, working platforms shall be installed prior to working. Before excavation, method of excavation, type of support needed, shoring and stability of ground shall be inspected by competent person. Location of sewers, pipelines electric connections shall be verified and maintained after excavation. Dust shall be controlled. Excavated trench shall be well fenced or surrounded by safety signs and signals. Cofferdam and Caisson should be of god design, suitable material and strength. It should be of good construction and suitable and sound material and of adequate strength. There should be Means to reach workers at safe place for the event of an inrush of water or material. In case of structural frames, formwork and concrete work, provision and use of ladders, sufficient temporary supports, fixed platforms, suspended lifting appliances, safety harness, catch platforms. Erection and concreting shall follow specifications be not done during adverse weather conditions. Daily progress record indicating following precise procedures of casting. Loads should not be dumped or placed on setting concrete. A competent person shall check the formworks as planned and designs. All the materials of formwork shall be thoroughly checked. Pile driving equipment should be of good design firmly fixed at site ensuring stability and pile driving shall be done with inspection of competent person. Workers shall be prevented from falling to water and drowning with stable boats, pontoon, bridges or other waterways for working under water. Demolition of structural steel should be done tier by tier and members should not be dropped from height. Done by experienced and competent person following plan. Before construction, exposed electric lines shall be insulated or power shall be cut. Transportation, storage, use or disposal of explosives shall only be done by experienced and trained persons using PPE. There shall be adequate provision of first aid facility with first aid kit and medical person to counter the possible physical, chemical, biological, psychological hazards. Adequate and suitable lighting, including portable lighting where appropriate, shall be provided at every workplace and any other place for safe movement and working. Employer, without cost to the workers, as prescribed by national laws or regulations where other means are not possible for hazard control shall provide: safety helmet, boots, gloves, face shield, mask, and protective clothing as per the exposure. For workers welfare, there shall be separate sanitary, washing and sleeping facilities for men and women, facilities for changing and drying of clothing; accommodation for taking meals and for taking shelter during interruption of work due to adverse weather. Accidents to workers causing injury, loss of life, near misses, property damage, collapse of structures/ equipment/scaffolds, explosions, occupational diseases shall be reported to competent authority.

Behavior of contractors on safety management, lack of provision of PPE, poor safety awareness and trainings are barriers and government role for strict legal enforcement is needed (Tam, et al., 2004). Lack of safety standards, resources, commitment and priority to safety, training, rules, policy, competent worker, and absence of safety officer are barriers to safety (Buniya, et al., 2021). Buniya suggested appropriate governance system to support safety, establishment of legislation with

enforcement and commitment of management for construction safety. Othman, et al., (2020) identified the 21 success factors influencing the implementation of construction safety programs in developing countries by extensive literature and interview with Iraqi construction experts. He found the emphasis on the importance of management commitment, safety training, enforcement of safety rules and regulations, stakeholder collaboration, technology (information modeling, use of sensor and wearable devices to monitor workplace) as new factor.

From above literature, the factors influencing the construction safety can be summarized as shown in figure 2:

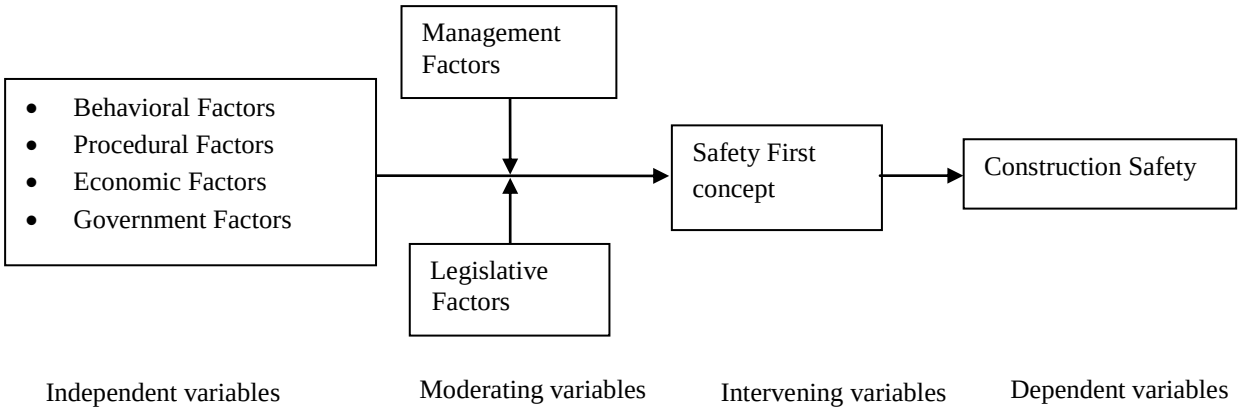

Figure 2: Conceptual framework for factors affecting construction safety

Methodology

Descriptive research design and quantitative research design was adopted to execute in systematic, planned and organized manner. However some qualitative inquiries were also made to understand the phenomena in detail. The study area was Gandaki Province, study population was 80 number of construction completed bridges in province and sample was 30 number of completed bridges selected using convenience sampling for quantitative research design.

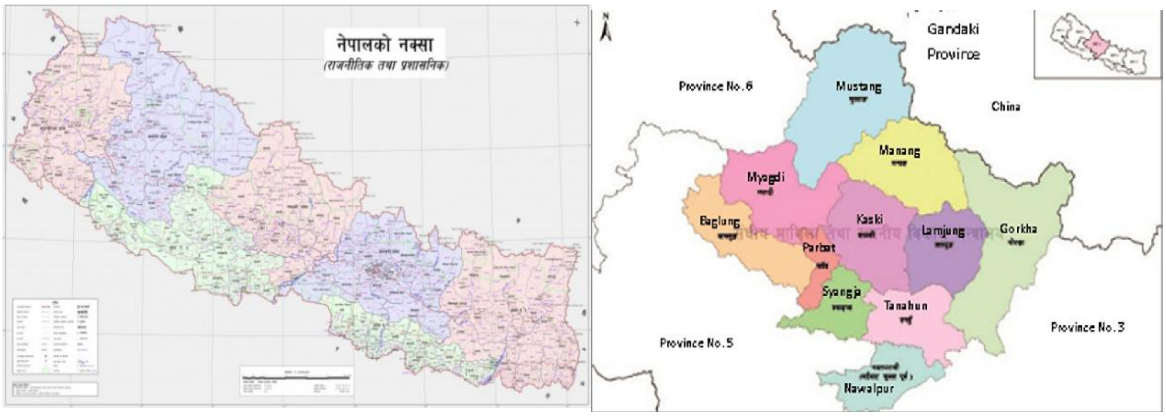

Figure 3: Political map of Nepal and Gandaki Province

Structured questionnaire was used to collect primary data from the respondents. Thirty respondents directly involved in bridge construction management for assessing the present construction safety and 57 respondents for studying the perception of implementers towards present construction safety and recommending improvements for it. The sampling was done using convenience sampling technique and the population size was 90. Secondary data were collected from different reports, researches, books and journals. Then the data were edited, coded, classified, tabulated and simple statistical tools like mean, average, percentage, ranking, RII were used to analyze the data and then results were presented in simple graphs, charts for discussion and interpretation.

Fourteen indicators for construction safety status were set based upon NBC: 114, Safety and Health in Construction code of ILO and contract document to assess the present status of construction safety. Six indicators were established to explore the consequences of applied construction safety in Bridge construction project implementation based upon: importance of safety for construction industries (Shrestha, 2012) and Consequences of poor construction culture (Ross Technology, 2021).

Seventeen statements for construction safety improvement were questioned through five point Likert's scale based upon six categorized safety factors to check respondents Relative Importance Index (RII).

Reliability and validity was ensured in this research by following ways:

- Content coverage by and representative samples from varying location and type.
- Use of consistent tabulation, analysis, presentation and interpretations of results.
- Respondents were involved in bridge construction, management and policy level.

Cronbach's alpha was found above 0.70 for the statements for construction safety improvement for employer, contractor.

Tool used for qualitative data collection were key informant interviews, site visits, observation, inspection and review of documents. The qualitative date were analyzed using descriptive and interpretative analysis.

Results and Discussion

Present construction safety status

Regarding safety of workplace and handling of materials, tools, plants, equipment and machinery, only 17% work place has been found well fenced with watchmen, in 83% open boundary and/or free movement. 70% bridge construction sites have been reported as absence of safety sign and signals and in 17% insufficient provision. Thirty percentage of bridge sites contains well managed storage of construction material and found poor storage or scattered in remaining.

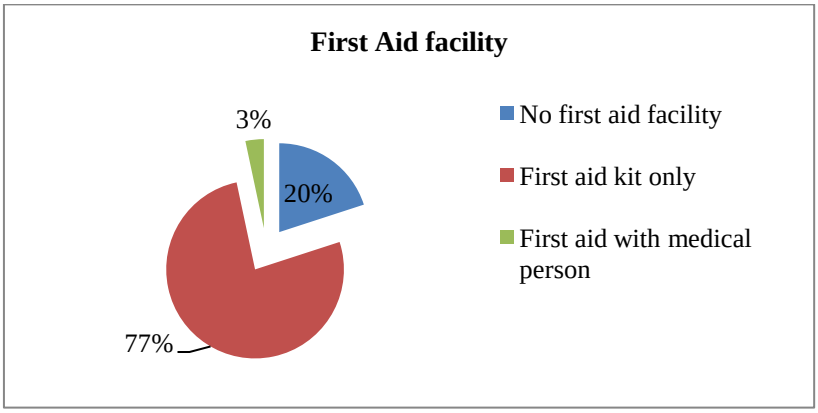

Figure 4: First aid facility and health provision at site

Figure number 4 Shows that no first aid facility in 20% bridge, managed just by first aid kit in 77% and managed with nearby medical person in 3%. Adequate provision and use of PPE has been found only in 7% bridge sites, no or limited provision and use in remaining.

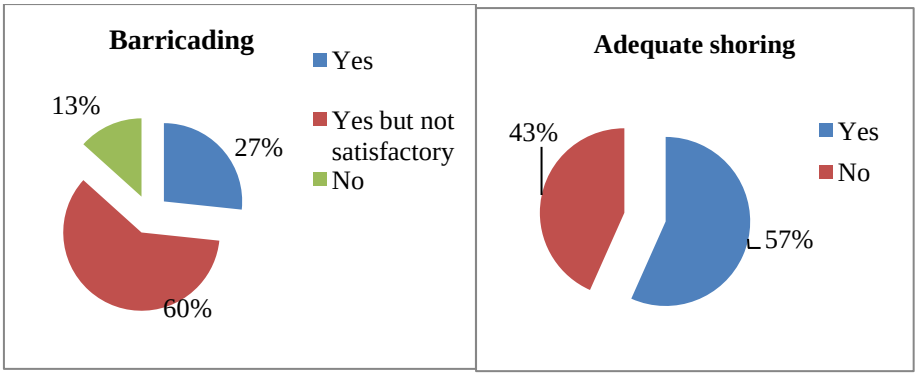

Figure 5: Adequacy of barricading and shoring during foundation excavations

Figure 5 shows that open trench and excavation area was well barricaded only in 27% bridges, just satisfactory in 60% bridges and zero barricading in 13% bridges. Inadequate shoring was found in 43% bridges. Also for foundation, inadequate supports, forms and shoring in 30% bridges and provided in 70% bridges. No method statement was found in 50% bridges. For construction of substructure, figure number 6 shows that only 3% bridges have provision of working platform and scaffolds were used as platform in rest 97 % of bridges.

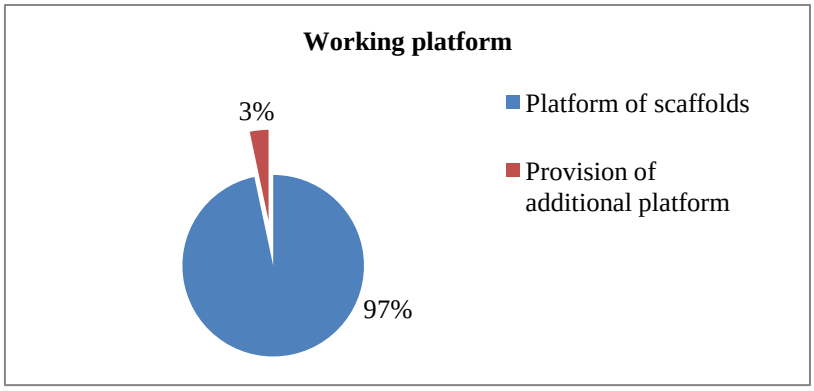

Figure 6: Provision of working platform during substructure construction

For superstructure construction, figure 7 shows provision and use of PPE has been reported only in 17% bridges and no or limited provision and use in remaining. For support base figure 8 shows that earthen embankment in 37%, stone/wood planks for 50% and concrete blocks for 13% bridges have been found. For tying vertical forms, gabion wires have been used in 27% of bridges, binding wire for 23% and tie rod in 50% bridges. 83% superstructures have been found constructed around rainy season.

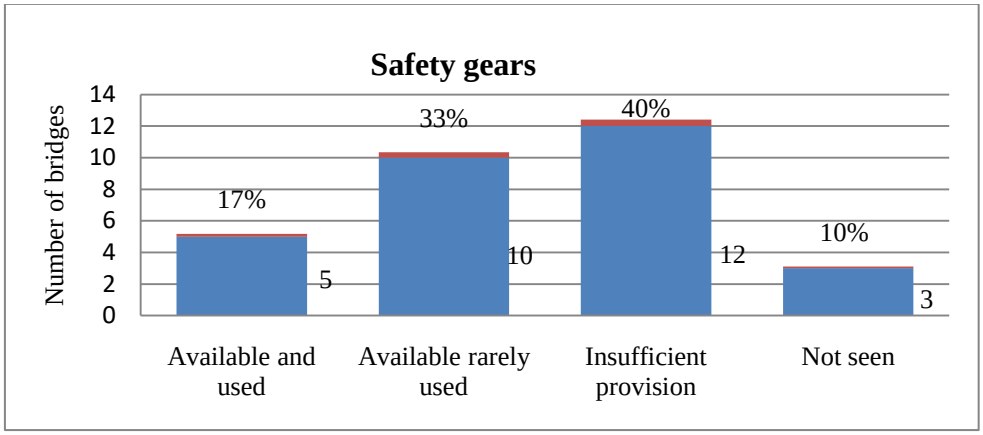

Figure 7: Provision and use of protective gears during superstructure construction

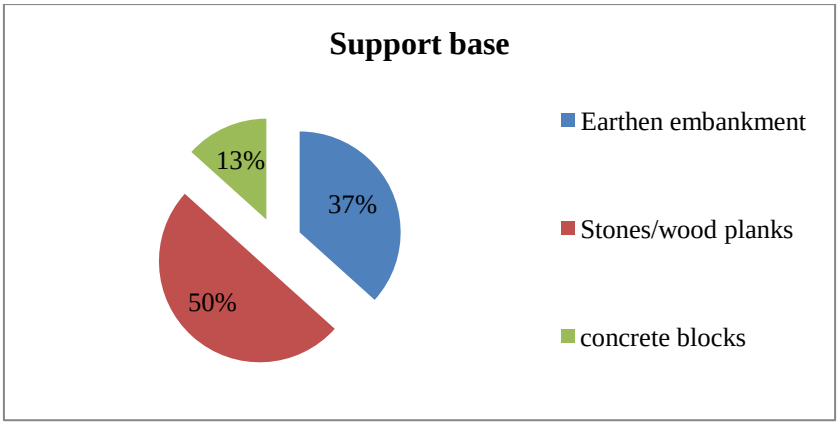

Figure 8: Support base resting for superstructure construction

Electrical connections near and above the site have been found insulated in 67% bridges and found risky in 33%. Figure 9 shows that welding and other electrical works found done by trained person using PPE in 27% bridges and by general worker with or without PPE in remaining.

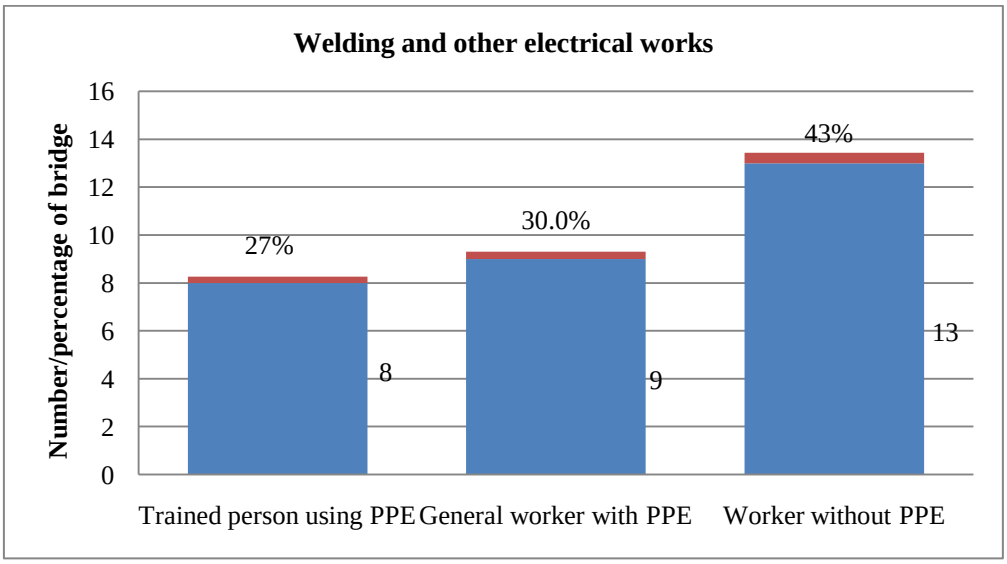

Figure 9: Welding and other electrical works

Regarding temporary works, figure 10 shows that in 63% bridges, formworks, falseworks, shoring, temporary crossings constructed as per knowledge of foremen and designed considering loads, strength and stability in 37%.

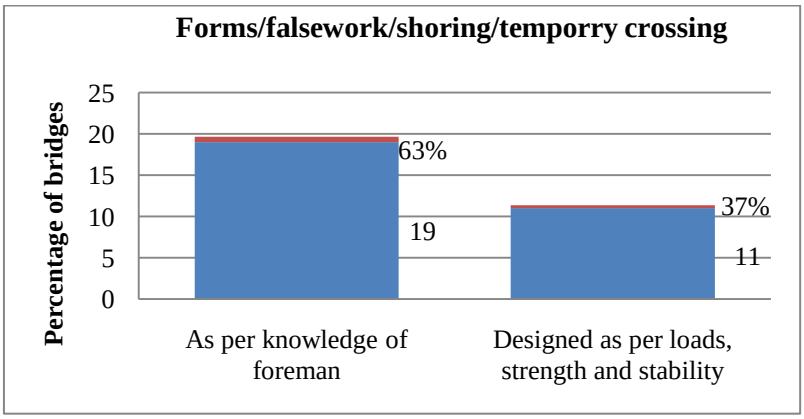

Figure 10: Construction of formworks, falseworks, shoring, and temporary crossings

Demolition plan has been reported only in 50% bridges. Posters, signs/signals installed adequately at demolition area in 7% bridges, insufficient installation in 50% and not 43%. Provision and use of safety gears has been found only in 20% bridges. Direct dropping to ground of dismantled materials in 40% bridges and passed one by one or using rope in remaining.

No use of explosives. No use of chemical in 87%, in 10% bridges chemicals used as per manufactures prescription and relied on workers in 3%. Regarding labour welfare, 40% bridge sites have managed drinking water tap and worker managed in 60%. Open toilet in 10%, single toilet/bath for 83% and separate for men/women in 27% have well managed accommodation inside camp and poor or no provision in remaining. Insurance for person, plant, equipment and work as per contract document was maintained. Abut information and training, it has been found that no job safety analysis, health and safety committee, safety plans/policy worker in 87% bridges. Figure 11 shows that 70% workers were found less or no aware about the construction safety. Only 20% have reported having trained workers.

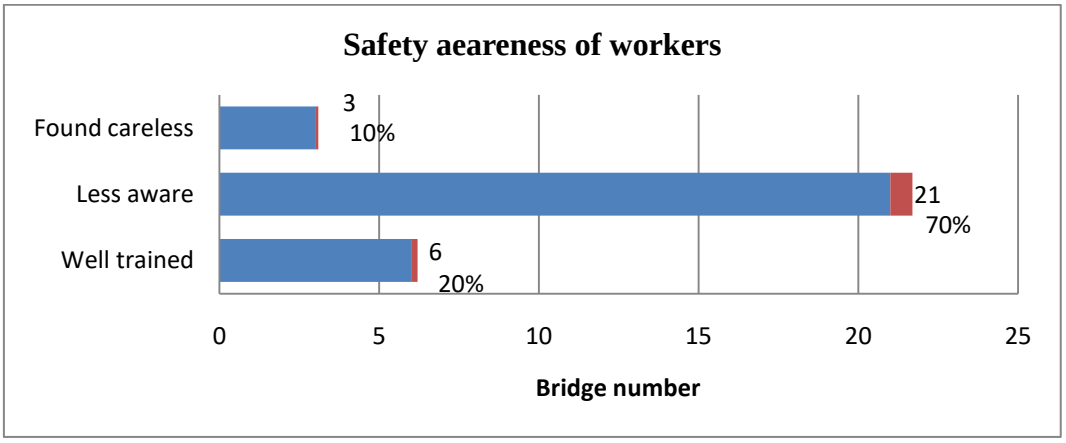

Figure 11: Workers awareness about construction safety

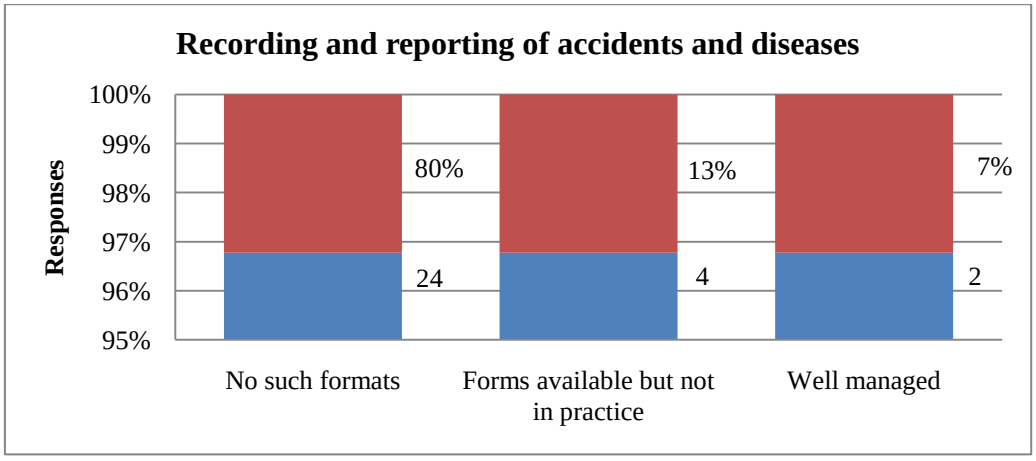

Figure 12: Recording and reporting of accidents and diseases

For reporting of accidents and diseases, figure 12 shows that in 80% of bridges, no forms for recording and reporting of accidents and diseases have been reported. Only 7% bridges have well records and reports. No separate safety supervisor in 90% of bridges.

Most of the bridge constructions do not comply with the construction safety standard provisioned in NBC: 114, construction safety and health code of ILO and contract document. Only little number of bridges is found to be constructed with priority to the construction safety.

Perception about construction safety practices

Figure 13 shows that 57% respondents recommended administrative/Engineering hazard prevention methods, 11% recommended for elimination/substitution and 32% still perceive that use of PPE is the

best hazard control method. 14% respondents felt that present safety practice is adequate and 86% emphasized for improvements on it.

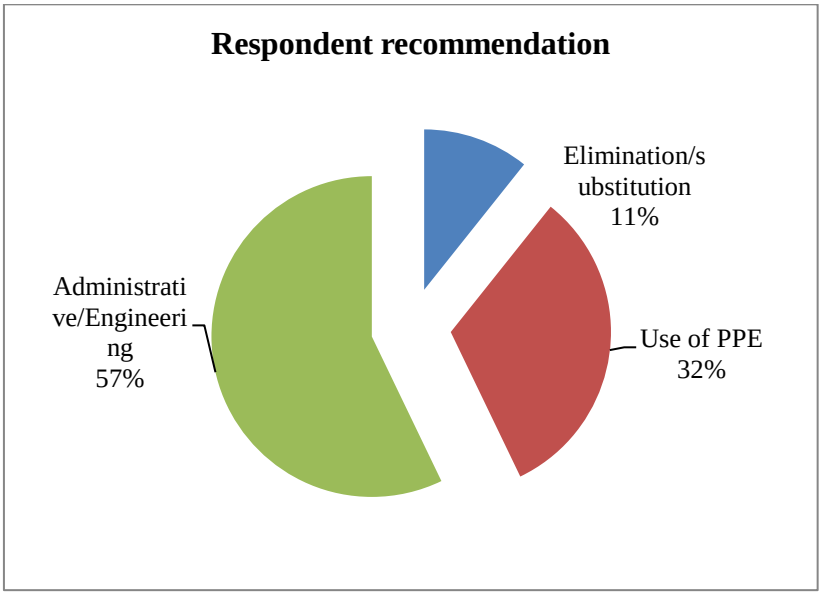

Figure 13: Hazard prevention method recommended by respondents

The study result reveals that the present construction safety practices are not enough and need much awareness and strict enforcement of rules regulations and legislations. Still one third of the implementers think that use of PPE can control the hazards.

Consequences of construction safety applied in the Bridge project implementation

The major risks/hazards are :falling from height, collapse of structure due to weak support, hit by falling objects, slip/trip/low falls, handling of steel parts, dust followed by electricity, noise, crushing, vibration, hazards due to prestressing, chemical, animal bite, drinking tranquilizing and working. Below table shows the level of accidents faced during construction. Figure 14 shows the weightage of different bridge construction accidents. Vehicle accidents for the bridge construction have been reported in 43% of bridges.

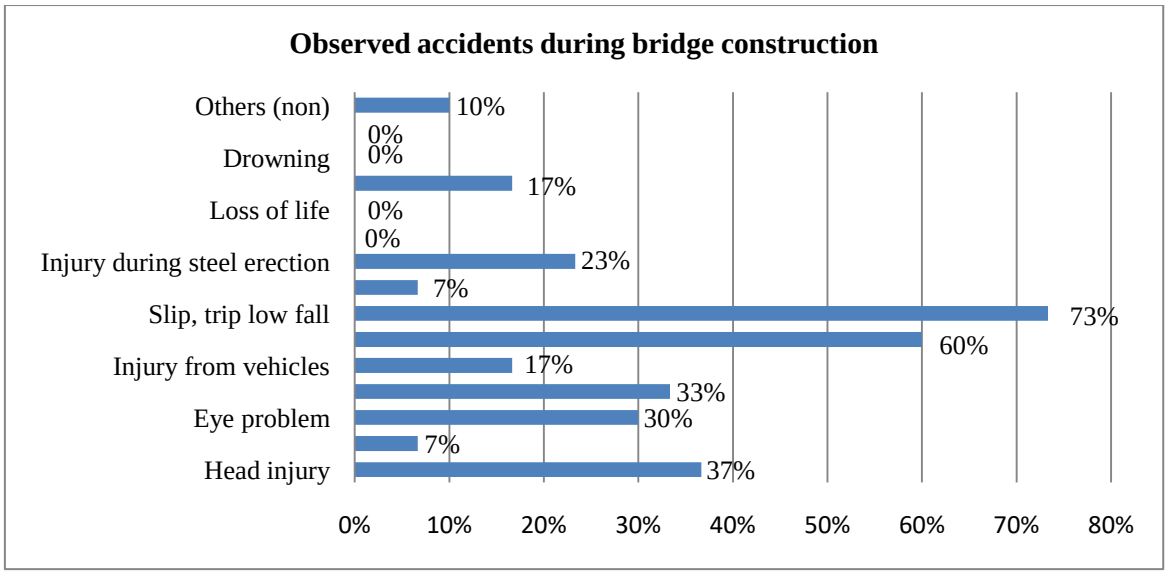

Figure 14: Observed accidents during bridge construction

23% bridges have been delayed, 27% have cost overrun due to construction safety issues and 77% not delayed and no cost overrun in 73%. Safety factors increasing the cost have been found as: frequent tool/machine/equipment damage and replacement, reconstruction of washed/collapsed temporary/ structural components, repair of defective constructions and replacement of materials. The study result reveals 43% of bridges faced collapse of forms/scaffolds/falsework for superstructure, 40% failure of formwork/shoring in foundation, 33% formwork for substructure, 30% temporary river crossing, 23% superstructure concrete, 17% footing concrete/coffer dam.17% bridges did not faced any collapsed during construction. Washout/damage of materials/equipment , foundation/diversion collapse, collapse of river crossing/staging, collapse of steel erection/supports have been reported as a result of work in adverse weather (rain, wind, snow).

Figure 15 shows that 73% local peoples lost land, 57% reported about dust/noise, 53% damage of irrigation canal, 33% damage of water supply, 17% damage of electric connections and 3% responded that blockade of adjoining road for few days during bridge construction. 87% responded that productivity of workers decreased due to poor bridge construction safety and 53% reported that there is frequent turnover of workers at construction site. Poor concrete due to failure/deformation of forms have been reported as: 60% in footing, 53% in abutment/pier, 37% in girder, and 23% in deck and abutment/pier caps. In addition, substandard quality as consequences of poor construction safety has been reported as shown in below figure 16.

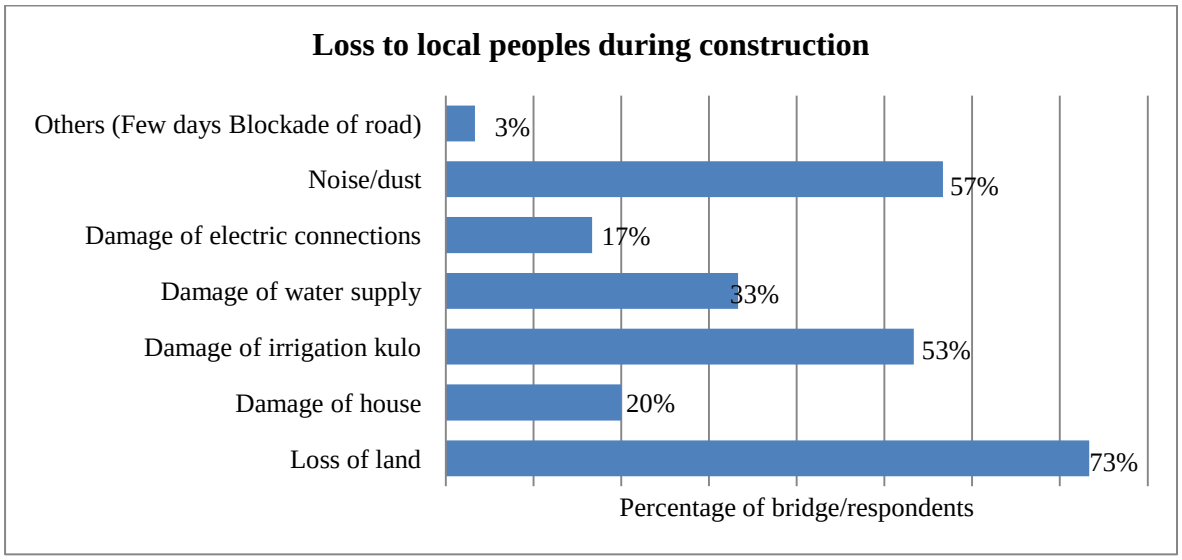

Figure 15: Loss faced by local peoples during bridge construction

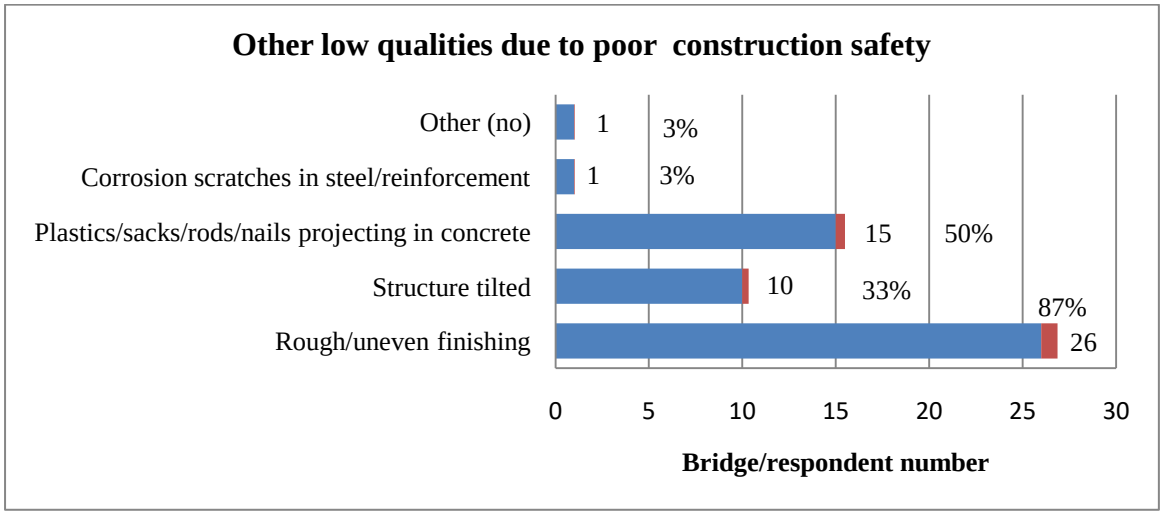

Figure 16: Low qualities due to poor construction safety

Under legal issues and reputation, 27% respondents reported about presence of issues of loss of land, 10% loss of irrigation canal and no issues by 63%.7% respondents reported that reputation of contractor was excellent in bridge construction safety, satisfactory by 53% and poor by 40%. As bridge construction is risky and more technical, it is obvious that there occurred several consequences as the results of poor construction safety. More deformation found in foundation and substructure might be due to thinking that these structures are partly underground. The consequences found during the bridge construction implementation may also be associated with other factors along with construction safety. Fortunately fatal accidents have not been found.

Relative Importance Index (RII)

The ranking of the statements for improving construction safety has been tabulated below:

Table 1 Ranking of statements for construction safety using RII

Statements	**RII**	**Rank**
1. Behavioral Factors		
i. Contractors should show willingness towards construction safety management.	0.925	2
ii. Workers shall be committed towards use of PPE	0.882	8
iii. All individuals involved in construction show their attitude thinking safety as their responsibility.	0.864	12
2. Management Factors		
i. Management shall be committed and supportive to implement construction safety	0.893	6
ii. Top management shall be aware and well trained	0.864	13
iii. Safety shall be regarded as first priority	0.929	1
iv. Authority and responsibility should be allocated properly (employee involvement)	0.871	11
v. Competent workers shall be selected (right person in right task)	0.904	3
vi. Adequate safety motivation shall be provided to all	0.879	9
3. Government Factors		
i. Government should play more strict role in enforcement of construction safety rules regulations as per legislation	0.904	4
4. Procedural factors		
i. Each implementer shall have safety committee, policy, hazard identification and response plan containing safety officer.	0.854	15
ii. There should be regular safety inspections, trainings, meetings and reporting.	0.889	7
iii. Good communication and team work	0.904	5
iv. Should use technology (use of sensor devices to monitor construction safety)	0.779	17
5. Legislative factors		

i. Formulation of safety legislations (rules, regulations and standards) more specific to bridge construction.	0.850	16
6. Economic Factors		
i. There should be sufficient resources (time, money, safe work methods, information)	0.864	14
ii. There should be provision of adequate budget in contract for construction safety management including purchase of PPE and protective clothing.	0.875	10

The Relative Importance Index (RII) shows that the respondents have high level of acceptance of the statements for suggesting improvements in bridge construction safety.

Conclusion

The study reveals that the majority of bridge construction sites are not well fenced. There are a number of cases where improper storage of materials, poor provision of PPE and protective clothing as well as lack of first aid facilities and labor welfare in addition to inadequate maintenance of construction tools and equipment are found. Absence of safety plans and demolition plans as well as method statements, inadequate supports, forms and platforms for working and inspection are common in the Nepalese bridge construction sites. Also, poor management commitment, low level of contractors willingness, and lack of workers awareness has been found towards construction safety. A perception that use of PPE is more effective than engineering and administrative hazard control measures still exists at managerial level. Lack of JSA, safety training, awareness, recording and reporting of accidents and diseases are reported in most of the bridges. Due to poor construction safety practices, accident of workers, vehicle accident, collapse/damage of bridge parts/components, collapse of temporary structures, washout of materials, tools, equipment and machines as well as damage to land, irrigation canal and water supply are reported. Similarly, cost and time overrun, substandard bridge quality, reduced workers' productivity, increased workers turnover, decreased reputation of the contractor are the consequences of poor construction safety measures. This study has recommended seventeen improvement statements for construction safety from extensive literature review and some inquiries with the experts.

The results of this study are expected to help implementing agencies to judge the construction safety practices they are applying and think forward for the improvements. Additionally, they might support policy makers and government to formulate bridge construction specific safety codes, guidelines and legislations and their stricter adherence. Though this study focused solely on construction safety practices, there might be other associated factors too. Further research in this topic may address additional issues that are relevant and highlight the need for formulation and strict implementation of specific codes, guidelines and legislations in all locality. If the bridge building is not in compliance with the construction safety requirements, the product will be of low quality leading to several accidents (personal injury, loss of life, loss/damage of goods, property) and huge loss to Government and people.

Recommendation

Safety should be regarded as first priority. Contractors should show willingness towards construction safety management. Competent workers should be selected (right person in right task). Government should play stricter role in enforcement of construction safety rules regulations as per legislation. Good communication and team work are equally important. Management should be committed and supportive to implement construction safety. There should be regular safety inspections, trainings, meetings and reporting. Workers should be committed towards use of PPE. Adequate safety motivation should be provided to all. There should be provision of adequate budget in contract for construction safety management including purchase of PPE and protective clothing. Authority and responsibility should be allocated properly (employee involvement). All individuals involved in construction must adopt safety as their responsibility. Top management should be aware and well trained. There should be sufficient resources (time, money, safe work methods, and information).

Each implementer should have safety committee, policy, hazard identification and response plan containing safety officer. In this context, formulation of safety legislations (rules, regulations and standards) more specific to bridge construction is very essential. The contractors should use modern technology (use of sensor devices to monitor construction safety) for better results.

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