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A Study on Construction Challenges of Bridges in The Hilly Areas

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ABSTRACT

A Bridge is a structure built to span a valley, road, river, body of water, or any other physical obstacle. Designs of Bridges will vary depending upon the function of the bridge and nature of the area where the bridge is to be constructed. The first bridges were made by nature itself as simple as a log fallen across a stream or stones in the river. The first bridges made by humans were probably spans of cut wooden logs or planks and eventually stones, using a simple support and crossbeam arrangement. Some early Indians used trees or bamboo poles to cross small caverns or wells to get from one place to another. A common form of lashing sticks, logs, and deciduous branches together involved the use of long reeds or other harvested fibres woven together to form a connective rope capable of binding and holding together the materials used in early bridges. Hilly region pose unique problem for bridge construction. In a restricted hilly area itself climatic conditions, geological features and hydrological parameters vary considerably. Keeping in view the bridge site and various constraints, type of bridge and method of construction are to be selected carefully for safe, economical and successful completion of bridge construction. India, a country with a total area of approx. 3.2 million sq. km. has around 23 % of its area covered with densely forested, thinly populated hills. Human habitation and Vegetation spreads to altitudes as high as 14000 to 16000 feet above Mean SeaLevel.

KEYWORDS: Bridge, Hilly, Construction, Challenges

I. INTRODUCTION

Hilly region pose unique problem for bridge construction. In a restricted hilly area itself climatic conditions, geological features and hydrological parameters vary considerably. Keeping in view the bridge site and various constraints, type of bridge and method of construction are to be selected carefully for safe, economical and successful completion of bridgeconstruction.

Various challenges that come across while constructing bridges in hilly area are

1. Construction of bridge across deepgorges
2. Construction of bridge on rivers with bouldarybeds
3. Construction of bridges in extreme temperaturezones
4. Construction of bridges on sharp turn on highway
5. Landslide or Debrisflow

Deep gorges, rivers with bouldary beds, extremely low temperature condition, high winds, landslide etc. in hilly regions require special attention to complete the activities of bridge planning and construction in a systematic way and are discussed here in.

BRIDGE CONSTRUCTION OVERVIEW

Planning and monitoring is basically what is to be done in due course of time, and how it is to be executed in the planned/allotted period for the particular bridge. All the pros and cons of the likely problems in the anticipated period need to be examined. Also the records of important points are made available at site with executives asfollows:

- Why the particular site was selected for thebridge.
- Why particular type of bridge is proposed. (structuralarrangement)
- Sitedata
- Proposal for preparationdrawing.
- Soil strata in the form of borelog.
- Model study detail if already done for scourassessment.
- Salient features of the bridge and quantities of each itemsinvolved.
- Upto date approved structural drawings.
- Details of all meetings and up to date decision if at alltaken.
- Decision making mechanism in case of any dispute i.e. Dispute Review Board (DRB) be alreadyfinalized.

II. LITERATURE REVIEW

N.P.Singh,Alok Panday(1998) Though bridges generally have a design life of 75-100 years, there have been incidences where strengthening or rehabilitation of the bridges is required before their designed life span. The reasons may be many but in the case of Balad bridge, which is located on the National Highway no.21A near Baddi (Himachal Pradesh), the rehabilitation of the bridge was required due to deep scouring and lowering of the bed at one of the pier location. As the bridge was designed for the maximum anticipated discharge and corresponding scour depth such a deep scouring was never expected. Such an unexpected deep scouring forced to explore in detail any other possible reasons for the scouring. After gathering the information from the local people regarding similar problems in nearby other bridges, it appeared that there may be other factors associated with the problem and this necessitated the detailed investigations not only for the Balad bridge but also for other nearby bridges. Detailed investigations were therefore done to identify the root causes of the problem and suggest the rehabilitation measures accordingly. The investigations and findings along with the methodology used for the rehabilitation and proposed bed protection works for the Balad bridge have beendiscussed and presented in the paper.

Ritesh Sharma(2015) The bridge was necessity since ancient days to cross rivers, valleys, hills etc ,the first bridge may be the fallen tree over these obstacles, further with the advancement of civil engineering so many types of bridges came into existence like "Steel and RCC bridges", and now a days it is symbol of development for any country. The necessity and various types of bridges included in this review with history of worldwide and Indian bridges and there classification based on material used for the purpose. A Bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley. In other words, bridge is a structure for carrying the road traffic or other moving loads over a depression or obstruction such as channel, road or railway. A bridge is an arrangement made to cross an obstacle in the form of a low ground or a stream or a river without closing the way beneath.

Lata ShamraoDhandore(2018)

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Fahimeh Zaeri(2014) Bridge construction projects are inherently complex and iterative, and these place great demands on project management to apply innovative approaches for more comprehensive analysis of performance data under uncertain conditions. Although new technological-based methods such as simulation have proven to be powerful techniques to cope with cyclic and uncertain project behaviours, implementation of simulation-based modeling is below par in the construction domain especially in bridge construction. This paper presents information on significant role of recent modeling methods in the construction domain. The study is an aspectofwider research thatexplores capabilities of simulation-based methods in scheduling and managing of construction projects in New Zealand by considering their repetitive, uncertain and complex features. The study design and data collection are briefly described to demonstrate the power of simulation technology in bridge construction management. It is hoped that the study will benefit both construction planners and managers.

CASE STUDY

Landslide Hazard Zonation by Gopal Sharma In this study, a detailed GPR survey is carried out in conjunction with remote sensing technique

The area taken up for study is the Kattery watershed (The Nilgiris District) situated on the Coonoor - Ooty highway with an area of 2000 hectares. It lies in the Ketty valley at an elevation of 2100mt MSL, global position latitude 11° 22” 01’ N longitude 76° 44” 32' E This Ketty valley is one of the biggest in South India and supports both annual and perennial crops. The watershed drains into the Katteryreservoir.

Kattery watershed is the apt choice of study because it has all factors related to the study. It has various agricultural practices, human inhabitation, communication systems (road & rail), large spectrum of land terrains, high intensity rainfall from both SW and NE monsoons, and finally draining into the kattery resevoir.

s to prepare Landslide Hazard Zonation map of Katteri watershed in the Nilgiris-Tamil Nadu, India. Thematic maps prepared for slope, Lineamentdensity.
Drainage density, Land cover/Land use, Aspect, lithomarge thickness and Geomorphology using LANDSAT, TM and ETMimagery, topographic map of l: 50,000 scale, and various other factors wereanalyzed in the GIS environment. Slope - Slope is an important factor in the analysis oflandslide.
As the slope increases the probability of the occurrence of landslide increases because the shear stress of the soil increases.
Land use pattern - Changes in vegetation cover and cropping pattern often contribute to landslides (Glade, 2003). From various studies, it is learnt that land use pattern of thick afforestion area and deep root helps to stabilise the slopes. The areas with thick vegetation were less prone to sliding with reference to the area with mild or no vegetation. (Gokceoglu and Aksoy,1996).
Drainage - Drainage plays a vital role in weathering and hence in turn to landslide, the coarse drainage locations are more prone than that of finer drainage i.e, more the drainage density, less is the area susceptible tolandslide.
Lineament - Lineaments are the rectilinear, linear or curvilinear features of tectonic origin observed in satellite data. The landslide susceptibility is more in area of high lineament density andintersection.
Aspect - It has been analysed that in north facing slopes the landslide occurrence is comparatively low, with reference to the south facing slopes. The landslide phenomena gradually increases from north to south and then declines. (Dai and Lee,2002).

BRIDGE FOUNDATION AND SUBSTRUCTURE

Foundation construction for any large bridge takes time. Problems encountered during construction of foundation depend upon type of foundation, soil strata encountered, equipment/plant deployed and logistic problems. Construction difficulties anticipated during the execution be kept in view while planning the works/ period for the job. Foundation can be opened foundation, pile foundation, well foundation or any other types of foundation.

In case of well foundation, the various type of soil are encountered and it becomes difficult to give any clear time schedule about the sinking of wells unless the soil details are very clear and the anticipated profile matched with the actual encountered. In case of bouldery and clayey soil the rate of sinking schedule is likely to be slow when compared with the sandy soil. Also there may be requirement of pneumatic sinking technique subsequent to open grabbing due to difficulties in sinking of well. As

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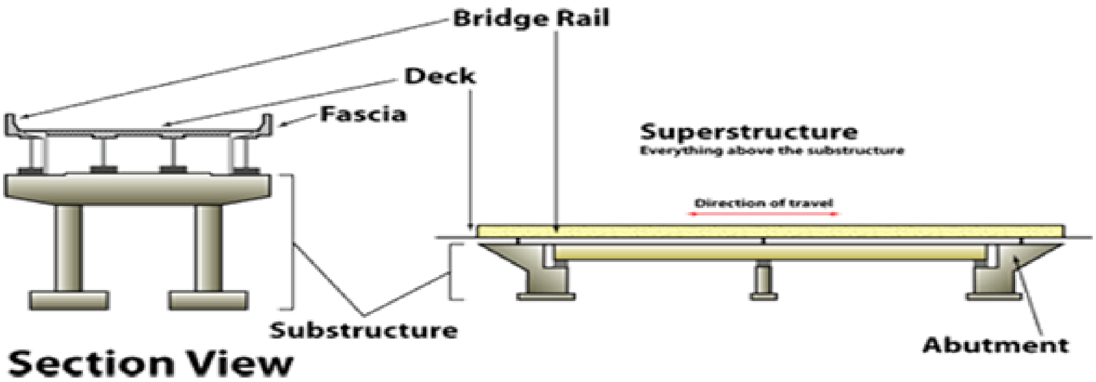
the cost of pneumatic sinking is very high, this should be deployedjudiciously.
In such cases, there is need to keep the details of all the sinking difficulties in a systematic order and this can be reviewed in consultation with decision making authority. Review of soil parameterif

required be given more attention and wherever required the details may be referred to material testing laboratory but within the timeschedule.

This may be helpful to recommend revision in foundation level, wherever possible based on soil data report. Tough strata in the foundation stage should be considered as engineeringfriendly.

Superstructure
For particular site there are numerous structura arrangements possible. Final proposal be made based on the greater examination of site condition may be technical, aesthetic and construction methodology. Special care need to be taken in case of deep



Proposal recommended for site should be well read in advance. After the proposal has been finalized for particular bridge, the construction can be planned. The quantities of each items involved and execution method be listed. Basically method statement should be kept ready for overall execution including job estimate. This data will be kept to ensure smooth progress of project.
Management of Construction Activities
Management of bridge construction demands that construction manager to reorient all the resources in such a way that the project is completed without any time/cost over run. Output of the work depend upon how best the activities are managed which will vary from site to site based on many factors.

Based on the experience, various aspects be identified for efficient construction management. Schedule of construction based Critical Path Method (CPM) be prepared along with major milestone and Bar Charts. Latest software management tool can be used for this in case of a major bridgeproject.

Design of Bridge is a post sanction in case of departmental construction and after tendering action in case of bridges throughout contract. It is necessary that design must be preceded by at least six to eight months or say 50% ahead of execution of concerned event. It has to be ensured that this should be completed well in time. Reviseddesign if any should be updated and clarified without delay. Observation on the approved design drawing if any be passed to design office immediately to make the change.

In case of foundation where design soil parameter needs to be adhered to. These may vary on actual execution and require review of design. To keep details with design office it is necessary that progress of foundation work be well informed to the design office.

Plant Management
Requirement of equipment/plant be assessed systematically and accordingly action may be taken to arrange this for a particularjob.

- Quantum of work covering allthe items with specifications.
- Time available for workexcution
- Details of equipment and also minimum requirement as per job position.
- Rated capacity of equipment/plant
- Assessed capacity
- Schedule ofmaintenance
- Inventory of spare partsrequired

- Repair cover toequipment/plant

The layout should ensure minimum movement of material, equipment and personnel of the area is an essential condition, for operation of some equipment for example tower crane operation not possible at heavy winds speed. Stone crusher if required for site should be suitablylocated.

A stores should not be located in the path of dust, flow. The service road should be properly maintained. Receipt and despatch of equipment be kept in proper format to keep of details of its utilisation atsite.

After staff has reported at site necessary action should be taken to utilise all the equipment. The required facilities for servicing and repair must be established to meet requirements.

Material Management
Material management is a parallel activity along with start of the Project. This cover procurement of camp material, office equipment, major purchased items, such as aggregates, sand, cement, steel, structural steel, shuttering consumables, electrical fittings. Forecasting of quantities and cost of various items on monthly basis must be done at least three to six months in advance which should be regularly reviewed.

Finance Management
No project or project management can be meaningful without this. In case of Government work the manager should get his budget fixed on monthly basis, on the basis of work done or minimum to be fed at site, on the decision of higher authorities. Key to measure financial planning lies in taking all above action and taking suitable measures at appropriate times to ensure that individual inputs are achieved to the maximum and capital investment kept at the lowest level.

Quality Management
Quality of work at site is most important activity and manager should always grapple to improve the same. Training to staff should be provided to update the quality control measure and it should become part of the work culture. At site laboratory be established to check the quality ofconcrete.
Tests be analysed at site based on the size of job. Mix design should be prepared based on the latest code and to produce the concrete of desirable strength.
Compaction of concrete be given more attention before final setting. Latest guidelines issued by IRC and MORT&H be followed for systematic quality assurance.
Safety Management
Safety of employees at site should be observed very seriously. All the workers be given briefing about the safety requirements based on the site hazards. Specially when the simply supported structure is attempted on deep gorge, suitable arrangement should be made to avoid any accident at site during insitu casting of superstructure. Also in case of foundation if the deep excavation is involved, the quality of surrounded soil be kept inview.

There are incidents where few workers got buried in deep excavation due to sudden slide, this should be taken care. In case the well foundation is being attempted using double drum winch care need to be taken during grabbingprocess.

During the diving process the proper coordination needs to be made between the diver and attendant to intimate about the problems if any, for which local signaling arrangements used, this can be finalised at site based onconvenience.

In case the pneumatic sinking is being used for well foundation, following safety measures, may be observed:
- Slowdecompression
- Accelerate circulation of air
- Duplicate and spareequipment
- Illumination inside workingchamber
- Signalingarrangement
- Caution about incidentalloading

These precautions should be seriously followed to avoid any catastrophes at site. Safety management is also important in case on staging shuttering for superstructure. There are cases in the past where the collapse of shuttering/staging has led to loss of life. This needs check in before casting the superstructure. In case steel truss is being used as a staging arrangement, design and launching arrangement be thoroughly checked.

Documentation Management
Document management during the contract is an art in itself. Proper and systematic management of documents is utmost requirement for department as well as contractor. All the details should be property vetted by both the parties. Better documentation will avoid any disputes during the currency and after completion of contract (i.e arbitration cases areavoided).
This needs special attention of the managers of both sides. Most of the cases being

dealt by the arbitrator in our country, due to lack of understanding between two parties which, are further affected by improper documentation. In fact better documentation reflect the system of management in any project. Control estimate is required to be prepared annually to assess the job position. This should include work done till date and balance work in terms of money.

This will be a guiding principle to progress the job in later period till completion. This practice is a must in all major bridge under construction. As project management has evolved, documentation has become a key skill particularly as projects become more complex and difficult. Organised documentation is the best defence against claims. Documentation that every project manager must have at their disposal are as under:

Proposal and Bid Estimates

These documents describe how the contractor envisioned the construction of the project and his plan to accomplish the work. It includes information about costs and schedule as well as constructionmethods.

Project Schedule

This is one of the most overlooked project records and it can provide the best documentation in a claim situation. The original baseline schedule sets the mark for monitoring the effects of any delays or unforeseen project disruptions.

Project Change orders

Any variances from the original contractual requirements must be documented and separated from the original scope of work requirements.

Daily reports, time sheets, letters of correspondence and meeting minutes or any other documentation discussing agreements made between parties should be readily available.

Personnel Management Manager should put the engineers, to activities they can perform better. Individual differences should be studied in detail to assign the suitable job to engineers, administration and accountstaff.

Manager should be a good Psychologist to assign the work based on the inclination of the people at work. A considerable free hand be given to see what an individual can produce. He should be guided from time to time and work be kept on progress.

Decision making circulated, critical activities be cleared by manager after proper deliberations. Also care must be taken to select a new entrant suiting to the job for requirement.

MAJOR ECOLOGICAL PROBLEMS

Deforestation:

The association between deforestation and slope instability has been a subject of considerable research. Deforestation brings about erosion and soil movement is generally accepted, but opinions differ on its impact. So far as "Creeping" slopes are concerned, greater creep velocities are found in slopes covered by trees in the region of Tamilnadu(Nilgiri) nov,2007 than in slopes merely covered by grass in region of rain forests (Between 1849 to1992).

Nilgiri(1973 to 1995) reported that deforestation leads to loss of mechanical strength imparted by rock system. Reinforcing power of roots is also demonstrated by the results of in situ block shear tests, which show that shear strength increases with increase in root density. At higher altitudes top green layer is very thin and takes hundreds of years tocome

A large number of trees along the roadsides are falling down due to road construction. Improper road construction results in soil erosion that may lead to uprooting of large trees and degeneration of lower plants. This way it leads to serious ecological imbalances affecting adversely run-offfactors, temperature gradient, surface radiation etc. Due to loss of vegetation, the velocity of run- off also increases that results in soil erosion, hence ofsoil-fertility

Hill face disturbance:
Natural inclination of hill face is disturbed by road cutting operation. Down hill movement of the land slides material and disposal of excavated mass from road construction degrade and deface the nature. Growth of vegetation is affected by the loss of topsoil that causes ecological imbalances

Drainage pattern interruption:
Velocity of run-off at the down hills increases to a very large extent due to construction of bridges and culverts on the road as well as due to cutting for getting proper communicationsystems.Thisleadsto eroding of banks and is a threat to the existence of trees and vegetation on the hill slopes. Sometimes lakes are formed by accumulation of debris from the excavated material and land slides.

A bridge was washed away thrice in six years because due to debris river was blocked and a temporary lake was formed. Same story was repeated at Nilgiri in 1992, where a big lake was formed and about ten villages were vacated in order to avoid any loss to human life.
This lake formed resulted in a loss of large number natural wealth both flora and fauna. This way natural drainage pattern of the area is disturbed by road construction, which sometimes results in flash floods also.
Water resources disturbance:
Natural water resources get disturbed due to blasting which is used during road construction activities Moreover, improper disposal of fuel, lubricants usea form of Water.

Siltation problem:
A large quantity of excavated material disposed on the down hill slopes is carried by the river that gets accumulated in the dams and reservoirs and reduce their life-span e.g. siltation.
A rate of Dam reservoir is very large which is due to large scale road construction in Sutlej catchment.

Destruction to flora and fauna:

Wild life gets disturbed due to blasting, hauling of machineries, shriveling sound of road rollers and noise of moving vehicles on the up-gradient. Destruction of key habitats such as resting sites, hollow trees, feeding and breeding grounds occurs due to road constructions. Some of the flora and fauna gets destroyed out right due to intrusion into forest for roadconstruction.

Pollution:

Tremendous pollution is created due to accumulation of debris down hill. Moreover, heating of bitumen throughhot mix plants produces a large number of air pollutants like oxides of sulphur, nitrogen and carbon

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Long chain aliphatic hydrocarbons and aromatic compounds are also the byproducts of this heating process, which are having carcinogenic property (Cancer producing) and special precautions must be taken for protecting the labourers working under such conditions on theroad construction site. Surrounding temperature gets increased and atmospheric humidity is lowered due to movements of machineries.

A vehicles, altering the physiological processes of the plants and thereby affecting their growth pattern. The alterations in the surrounding conditions causes interference of micro-organism life in the soil.

Destruction of medicinal wealth:

In the hill areas of Ooty out of 3000 species of identifies plants, over 500 species possess various kinds of medicinal properties. Hundreds of plants have ethno botanical importance. There are about 150 species of aromatic plants used in different kindsof cosmetics and having different medicinal properties.

But due to improper planning in road construction and processes involved during road construction, the natural wealth gets destroyed costing crores of rupees in spite of protecting.

PROTECTIVE MEASURES

In order to maintain balance between the road construction activities and environment certain protective measures have to be taken. Some of these measures are as follows:

Environment impact assessment:

Before starting the road construction operation, environmentalists must be consulted in the area of environment to this many order to avoid any ecologicalimbalance.

Geological investigation:
A geologist must be incorporated in the road construction work. Blasting and chippingof mountain slopes must be done under his instructions in order to avoid any geological havoc.

State of wildlife:
During the road construction loss to flora and fauna must be minimum. It should not be disturbed. An environmentalist must be consulted prior to road construction work.
Avoidance of unstable and fissureal zones:
Roads should not be constructed in lose soil and where erosion chances are more. In such cases the help of a soil Engineer must be taken, before starting any such activities.
Least disturbance to natural streams and gradients:
Natural face of the hill must be least disturbed while constructing the roads.Onl the required land must be used for thepurpose.

Restriction on reserve forests:
Road construction activities must be minimum on reserve forests in order to avoid any disturbance to natural wealth. This will help in maintaining the ecological balance.

Judicial way of doing work:
While cutting and disposing the debris special care must be taken so that there is no soil erosion and loss to flora and fauna.

Minimum blasting operations:
Blasting practice during road constructionmustbetotheminimumextent in order to avoid any dynamic forces causing movements of slip zones, cracks, fissures and weak planes.

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Half tunneling must be restored:
Incase of verticalrocky slopes half-tunnelingmust be restored. Ropeway technique:

In case of less densely thick population ropeway must be installed instead of going for road construction. This will provide protection to soil erosion, wild life and environment

Suitable drainagesystem:
Along the entire side of the road, a suitable drainage system must be provided so as to avoid any flash flood, soil erosion, damage to vegetationetc.
Restoration of natural springs and waterways:
Natural springs and water resources must not be disturbed during road construction process, otherwise it will be a great challenge to thenature.

Rebuilding of environment:
a) On suitable points, places must be provided that may act as scenic spots to theusers.

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b) Programme of social forestry mustbe taken upto the root level. The wastelands must be garlanded with trees, and valuable herbs and shrubs. The best example of social forestry is found in china where even single inch of wasteland is not left without plantation. Debris obtained during road cuttings must be accumulated at some appropriate place and plantation must be done on the same. This plantation will help in retaining the naturalenvironment.
c) Plantation must be done along the banks of rivers, nallaha etc. in order to avoid any further cutting of soil and to protect the water reservoirs and dams from moresiltation

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Small water tanks along with the proper drainage system must be constructed along the roadsides in order to protect both flora and fauna. Roadsides must be planted at war-level so as to give the best example ofafforestation.

DESIGN OF BRIDGE ONLANDSLIDES
AREAS

Landslide remedial measures are arranged in four practical groups, namely: modification of slope geometry, drainage, retaining structures and internal slope reinforcement. This chapter discusses the planning and designing aspects of the landslide remedial measures in each group and presents some illustrative examples. In addition, debris flow mitigation measures are discussed in some detail. Back analysis of failed slopes is an effective tool for reliable design of the remedial measures while advanced numerical methods are nowadays frequently used to design safe and cost effective landslide remedial measures

1. Landslide disaster mitigationoptions

Risk mitigation is the final stage of the risk management process and provides the methodology of controlling therisk.Attheendoftheevaluationprocedure,iti•s up to the client or policy makers to decide whether to accept the risk or not, or to decide that more detailed study is required. The landslide risk analyst can provide background data or normally acceptable limits as guidance to the decision maker butshould not be making the decision. Part of the specialist's advice may be to identify the options and methods for treating the risk.

- Accept the risk - this would usually require the risk to be considered to be within the acceptable or tolerablerange.
- Avoid the risk - this would require abandonment of the project, seeking an alternative site or form of development such that the revised risk would be acceptable ortolerable.
- Reduce the likelihood - this would require stabilization measures to control the initiating circumstances, such as reprofiling the surface geometry, groundwater drainage, anchors, stabilizing structures or protective structuresetc.

Reduce the consequences - this would require provision of defensive stabilization measures, amelioration of the behavior of the hazard or relocation of the development to a more favorable location to achieve an acceptable or tolerable risk.

Monitoring and warning systems - in some situations monitoring (such as by regular site visits, or by survey), and the establishment of warning systems may be used to manage the risk on an interim or permanent basis. Monitoring and warning systems may be regarded as another means of reducingthe consequences.

- Transfer the risk - by requiring another authority to accept the risk or to compensate for the risk such as byinsurance.

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• Postpone the decision - if there is sufficient uncertainty, it may not be appropriate to makea maximum decision on the data available. Further investigation or monitoring would risk

The relative costs and benefits of various options need to be considered so that the most cost effective solutions, consistent with the overall needs of the client, owner and regulator, can be identified. Combinations of options or alternatives may be appropriate, particularly where relatively large reductions in risk can be achieved for relatively smallexpenditure.

2. Landslide disaster engineeringmeasures
Surface water is diverted from unstable slopes by ditches and pipes. Drainage of the shallow groundwater is usually achieved by networks of trenchdrains.

Drainage of the failure surfaces, on the other hand, is achieved by counterfort or deep drains which are trenches sunk into the ground to intersect the shear surface and extending below it. In the case of deep landslides, often the most effective way of lowering groundwater is to drive drainage tunnels into the intact material beneath the landslide.
From this position, a series of upward - directed drainage holes can be drilled through the roof of the tunnel to drain the sole of the landslide. Alternatively, the tunnels can connect up a series of vertical wells sunk down from the groundsurface.

In instances where the groundwater is too deep to be reached by ordinary trench drains and where the landslide is too small to justify, an expensive drainage tunnel or gallery, bored sub- horizontal drains can be used. Another approach is to use a combination of vertical drainage wells linked to a system of sub-horizontal borehole drains.

Recent advances in the commonly used drainage systems include innovative means of drainage such as electro-osmotic dewatering, vacuum and siphon drains. In addition, buttress counterforts of course-grained materials placed at the toe of unstable slopes often are successful as a remedial measure. They are listed in Table 1 both under “Drainage” when used mainly for their hydrological effect and “Retaining Structures” when used mainly for their mechanicaleffect.
During the early part of the post-war period, landslides were generally seen to be “engineering problems” requiring “engineering solutions” involving correction by the use of structural techniques. This structural approach initially focused on retaining walls but has subsequently been diversified to include a wide range of more sophisticated techniques including passive piles and piers, cast-in-situ reinforced concrete walls and reinforced earth retaining structures. A schematic view of the commonly used retaining and slope reinforcementmeasuresisgiveninFig.3along with pictures illustrating two of these measures, namely large diameter caissons and ground anchors .

3. Debris flow mitigationmeasures
Among debris flow mitigation measures, check dams are the most typical.
Check dams in the stream capture debris flow directly and hold the sediment. Although check

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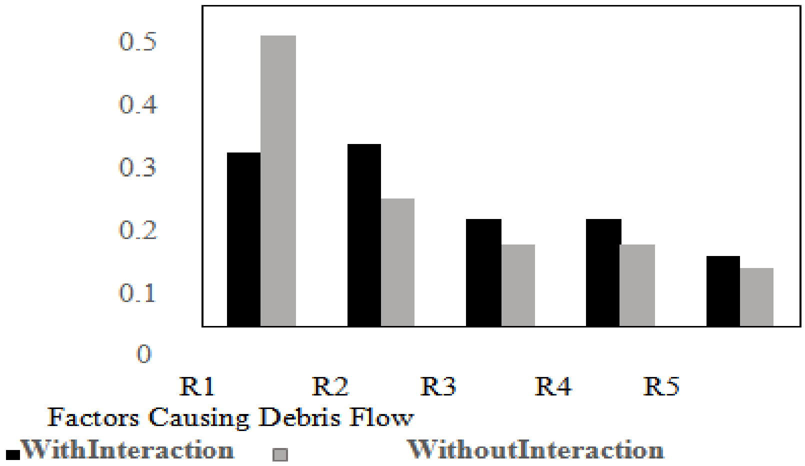
dams made of concrete are the most popular, some other types of check dams are also constructed for debris flow mitigation. Some relatively new types of check dams in ooty are presented in the following.



R1- availability of material;
R2-Peak discharge;
R3-Slope;
R4-Land Use and
R5-Proximity to Stream

Concrete check dams are the most popular. They are constructed not only to capture the runoff sediment directly, but also to decrease the volume and discharge runoff sediment. The latter function represents the so called ‘sediment controlfunction’.

The check dams filled with local sediment are used for construction cost reduction. This type of check dam is not made of concrete, but filled with sediments derived from the construction site and the inner sediment material is covered with steel walls. Steel walls are located in front of the dam and behind it . The construction of this type of dam can avoid the transport stage of the sediment from outside of the jobsite. It saves much time and cost during the constructionstage.

Check dams with pitching logs are sometimes used to harmonize the dam structure with the surrounding forest landscape. The dam body is made of concrete which provides enough strength against sediment and water discharge. Logs are used only for harmonizing with the landscape.

This type of dam is generally constructed in a stream where the debris flow discharge is predicted to be very small and where a good looking landscape area like a national park is present. Logs derived by maintenance thinning of the forest are usually used for dam construction .

Open-type check dams are popular and have been constructed at many sites for debris flow mitigation. Concrete slit dams and steel pipe grid dams are typical in Japan. Open type check dams allow sediment discharge to down stream, usually through the slit or open space, and sediment capture at the large scale flood and debris flow. The captured sediment is discharged to downstream little by little at the small scale flood. Therefore it is expected that the sediment pocket behind the dam body can be retrieved after the large flood or debrisflow.

This represents the sediment capture and retrieval function of this type of dam. In recent years, sediment discharge control function has also received attention. When there is a large discharge of water flow into the slit or grid, water back filling occurs because the cross- sectional area of flow suddenly decreases. As the water is accumulating behind the dam body, flow.

4. Back analysis of failed slopes to design remedialmeasures

A slope failure can reasonably be considered as a full scale shear test capable to give a measure of the

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strength mobilized at failure along the slip surface. The back calculated shear strength parameters which are intended to be closely matched with the observed real-life performance of the slope, can then be used in further limit equilibrium analyses to design remedialworks.

Shear strength parameters obtained by back analysis ensure more reliability than those obtained by laboratory or in-situ testing when used to design remedial measures.

In many cases, back analysis is an effective tool, and sometimes the only tool, for investigating the strength features of a soil deposit. However one has to be aware of the many pitfalls of the back analysis approach that involves a number of basic assumptions regarding soil homogeneity, slope and slip surface geometry and pore pressure conditions along the failure surface. A position of total confidence in all these assumptions is rarely if everachieved.

Indeed, in some cases, because the large extension of a landslide, various soils with different properties are involved. In other cases the presence of cracks, joints, thin intercalations and anisotropies can control the geometry of the slip surface. Moreover progressive failure or softening resulting in strength reductions that are different from a point to the other, can render heterogeneous even deposits before homogeneous.

5. Optimum planning and design of remedial measures by numericalanalysis

Nowadays the budget for landslide disaster mitigation works in many countries is continuously shrinking due to economical restrictions. Therefore cost effective landslide mitigation measures are hardly needed.

This goal can be achieved by the optimum planning and design of landslide mitigation measures taking into account the actual landslide characteristics, adopting new construction methods or cheaper materials and reconsidering the construction process options. The following presents some general concepts on the optimum planning and design of landslide mitigationmeasures.

Numerical methods are largely used in the planning and design of landslide remedial measures. These include 3-D seepage analysis for the planning of drainage works and 3-D limit equilibrium slope stability analysis or 3-D deformation analysis by Finite Element Method (FEM) for the design of restraint works such as stabilizing piles or ground anchors.

Formerly, when our calculation ability was limited by the computer availability and capability, simplified 2-D numerical methods have been used for both seepage analyses and slope stability evaluations in order to design remedial measures such as slope geometry modification, drainage works, retaining structures or internal slope reinforcement structures.

While it is apparent that the landslide processes are always 3-D, the 2-D seepage and slope stability analysis methods only treat longitudinal unit width sections of the landslide mass neglecting 3-D topographical and geological effects and 3-D pattern of the groundwater movement within the landslide mass which is also3-D.

In recent years more sophisticated and more reliable, computer based, numerical analysis methods have been developed and adopted for the planning and design of the landslide mitigation works. These methodsgreatlycontributetoasaferandmore cost effective design of landslide mitigation works.

As stated above, the groundwater movement within the landslide mass is affected by the 3-D shape and geological structure of the landslide mass. In order to take into account these 3-D factors in the design of the drainage works, reliable information on the 3-D topography and geology of the landslide area is needed.

The 3-D seepage modeling requires information not only on the site 3-D topography and geology but also on the 3-D distribution and variability of soil hydraulic and physical properties which govern groundwater movement. This type of analysis can more accurately simulate the movement of groundwater and therefore can result in optimum planning and design of the drainage works.

It is to be noted that more information on site topography and geology and more geotechnical investigations to better define the variability of soil parameters are needed for a 3-D seepage analysis as compared with a 2-D analysis. However the additional cost associated with the supplementary investigations is compensated by the more reliable and cost effective design of the drainageworks.

The above statement is valid also for 3-D slope stability analysis methods or 3-D deformation FEM analysis approaches when used for the design of the restraint works. 2-D slope stability analysis

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methods such as Fellenius or Bishop method, for circular failure surfaces, and Janbu or Spencer method, for non-circular failure surfaces, can be easily incorporated in simple computer programs or even used in hand calculations.

However they do not reflect the 3-D landslide topography and geology and the 3-D variability of soil mechanical and physical properties. Where the shape of landslide mass is like a whisky-barrel, with the cross-sectional sliding mass not only the resistant force at the toe but also at the lateral boundary resistant forces.

In such a case only a 3-D analysis can adequately reflect the effect of the resistant forces in the cross-sectional direction. In addition, 3-D analysis can consider the resistant force of the anchor works which have an oblique direction in respect to the longitudinal section of the landslidemass.

A 2-D analysis can not model appropriately oblique forces in respect to the longitudinal direction. As far as stabilizing piles are concerned, the 2-D analysis methods assume that the pile row acts as a wall providing a resistant force in longitudinal section.

However the actual situation is clearly 3-D and the 3-D location of stabilizing pile and their interval along the cross-sectional direction should be considered for an appropriate planning and design of the stabilizingstructures.

If the pile interval is too large, the soil between piles can move down slope and therefore the stabilizing piles do not play their role though they may have enough structural resistance.
Interaction between the piles and soil along cross-sectional direction should be considered in addition to the forces acting along longitudinal direction. 3-D FEM deformation analysis can adequately incorporate thiseffect.

6. Levels of effectiveness and acceptability that may be applie remedial measures Selection of an appropriate remedial measure dependson:
a) engineering feasibility, b) economic feasibility, c) legal/regulatory conformity, d) social acceptability, and e) environmental acceptability. A brief description of each method is presentedherein:
width and depth maximum at the centear) Engineering feasibility involves analysisof longitudinal profile and becoming smaller towards.

The lateral boundaries of the mass, we should consider in the general equilibrium of the geologic and hydrologic conditions at the site to ensure the physical effectiveness of the remedial measure. An often-overlooked aspect is making sure the designbridge.

b) Economic feasibility takes into account the cost of the remedial action to the benefits it provides. These benefits include deferred maintenance, avoidance of damage including loss of life, and other tangible and intangible benefits.

c) Legal-regulatory conformity provides for the measure meeting local building codes, avoiding liability to other property owners, and related factors.
d) Social acceptability is the degree to which the remedial measure is acceptable to the community and neighbors. Some measures for a property owner may prevent further damage but be an unattractive eyesore toneighbors

Environmental acceptability addresses the need for the remedial measure to not adversely affect the environment. De- watering a slope to the extent it no longer supports a unique plant community may not be environmentally acceptablesolution.

As many of the geological features, such as sheared discontinuities are not known in advance, it is more advantageous to put remedial measures in hand on a “design as you go basis”. That is the design has to be flexible enough to accommodate changes during or subsequent to the construction of remedial works.

This goal can be achieved by the optimum planning and design of landslide mitigation measures taking into account the actual landslide characteristics, adopting new construction methods or cheaper materials and reconsidering the construction process options. The following presents some general concepts on the optimum planning and design of landslide mitigationmeasures.

7. Invited presentations
The depth of the sliding surface is from 60 to 120 meters below ground surface. It has been estimated that the landslide involves on the order of 75 million cubic meters of soil and rock debris and covers over three square kilometers of landarea.

Failures in engineered slopes are often particularly revealing in that they demonstrate flaws in

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thinking, investigation and analysis from which lessons can be learned.

Examples include failed slopes that had been investigated using standard ground investigation and instrumentation techniques but where the true mechanism had been overlooked or missed.

It is acknowledged that whilst it is relatively easy to identify the key aspects of a landslide after the event, it is a much more difficult task to use that interpretation to make predictions regarding the hazard levels in other slopes.

Examples are given of where such lessons have been used to reassess other slopes and to make decisions regarding the need for landslide mitigation works.

In terms of mitigation, it is very important that an ongoing, progressive landslide is properly understood to ensure that correct and cost effective mitigation measures areadopted.

Monitoring is important for assessing an ongoing landslide risk but that monitoring must to be linked to models, identified through proper investigation and analysis that can then be tested through prediction andmeasurement.

SCOUR IN BOULDER RIVER BED

Flood damage has aggravated recently owing to artificial structures in high flow rare areas such as small rivers, which can lead to secondary damage. In this regard, studies are required to examine the conventional design criteria formulas to secure the stability of structures such as weirs and drop struc- tures. Although studies on the stability of these structures have been con- ducted through small-scale experiments, few empirical studies have investi- gated the hydraulic phenomena occurring near actual artificialstructures.

In this study, we fabricated real- size models of weir and drop structure at the ooty River Experiment Center and investigated the flow patterns.

The structures by applying the particle image velocimetry analysis technique with a flow tracker. We also measured the scour length in the waterspout sec- tion when the structures are overflowing, and compared it with the values calculated using the formula. Consequently, as the supply flow increases, the result is different from the value calculated using the formula given in the ex- isting design standard, and it is judged to be inappropriate for a small stream area with high flowrate.

Thus, it is necessary to consider the design factors such as energy gradient and the flow amount per unit width into weir and drop structure as well as the existing design factors in designing an apron sec- tion for a weir and drop structure.

The real-scale experiment with a weir and drop structure was conducted to in- vestigate the optimal apron length for the protection of downstream scour. Un- der the condition of 3% bed slope, the effect on downstream scour per flow rate was analyzed. The experimental flow rate was gradually increased from 1.7 m3/s to 5.0 m3/s to determine the upstream flow rate for five conditions, and the

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ex- periment was performed for the downstream boundary condition with outflow conditions.
The experiment was conducted after 3 h of water flow to measure the downstream scour length for each flow rate. During the experiment, the flow rate distribution around the structure was measured through two methods using a flow tracker and particle image velocimetry (PIV). PIV is a whole-flow-field technique providing instantaneous velocity vector measurements ina cross-section of a flow. This technique being a non-intrusive one, allows the application of PIV in high speed flows, boundary layer studies of fluids.

The technique is ap- plicable to a range of liquid and gaseous flows. The fluid is seeded with particles which are generally assumed to faithfully follow the flow dynamics. It is the mo- tion of these seeding particles from which the velocity information is calculated. It is done by taking two images shortly after one another and calculating the dis- tance individual particles traveled within this time.
The displacement field is de- termined from the motion of the seeding particles between the two images. The velocity field is obtained by dividing the displacement field by the known time separation.

A total of 25 measurement points for the flow tracker were selected with five points for five measurement lines, respectively downstream part of the structure, boulder stoneswithaD50of0.35mwereinstalledto quantitativelyexaminethedownstreamscour of the weir.

The stability of weirs and drop structures is evaluated in terms of overturning, activity, and settlement. Japan also specifies that the stability evaluation for the design of weirs and drop structures should be based on over- turning, activity, and settlement.

However, the current domestic River Design Standard provides only the regulations for the design segment and the shape in the design of weirs and drop structures, while specifying no criteria for external force and internal force calculation foreachstabilityevaluationitem.

Therefore, the design depends on judgments based on past experiences of structure installa- tion. Thus, it is difficult to determine how stable the currently installed weirs and drop structures are against floods.

The flow at the upstreampart of the weir shows that, after passing through the bight of the water channel, the flow concentrated to the left side of the channel at a maximumflowrateof0.845m/s,1.482m/s,

and 1.919 m/s for the aforemen- tioned experimental conditions, respectively.

A While the flow passed through the weir, the water depth decreased and the maximum flow rate increased to 1.946 m/s, 2.445 m/s, and 2.655 m/s, respectively.

At the downstream part, the flow passing through the weir became a supercritical flow, further changing into a subcritical flow after undergoing a hydraulic jump phenomenon at the down- stream part of the weir. According to the results of the PIV analysis, the up- stream flow shows the same flow pattern.

INCREMENTAL LAUNCHING METHOD

Bridge construction over deep valleys, water crossings with steep slopes, or environmentally protected regions can offer many challenges. The incremental launching method (ILM) for bridge construction may offer advantages over conventional construction, including creating minimal disturbance to surroundings, providing a more concentrated work area for superstructure assembly, and possibly increased worker safety given the improved erection environment

The ILM involves assembly of the bridge superstructure on one side of an obstacle to be crossed, and then movement (or launching) of the superstructure longitudinally into its final position. Despitepotential
advantages for certain situations, the use of the ILM for bridge construction has been very limited in the United States.

The objective of the work summarized in this report was to provide bridge owners, designers, and contractorswith information about the ILM. The incremental launching method (ILM) for bridge construction may offer advantages over conventional construction, including creating minimal disturbance to surroundings, providing a more concentrated work area for superstructure assembly, and possibly increased worker safety given the improved erection environment.

To clarify the ILM procedure and the current state of practice, a comprehensive literature search and survey were conducted. Recommendations pertaining to best practices for planning, design, and construction activities, as well as applications and limitations for the ILM are also provided. Case studies are presented, which provide specific ILM bridge projectinformation.

The use of the ILM for bridge construction will never be the most efficient way to construct every single bridge. However, it is thought that a wider understanding of the applicability and potential benefits would allow potential owners, designers, and contractors to make well-informed decisions as to its use for their upcoming projects.

The incremental launching method will never become the most economical procedure for constructing all bridges. The ILM requires a considerable amount of analysis and design expertise and specialized construction equipment. However, the ILM may often be the

most reasonable way to construct a bridge over an inaccessible or environmentally protected obstacle

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When used for the appropriate project, the ILM offers a number of significant advantages to both the owner and the contractor, including thefollowing:

- Minimal disturbance to surroundings including environmentally sensitive areas
- Smaller, but more concentrated area required for superstructureassembly
- Increased worker safety since all erection work is performed at a lower elevation

The ILM can be used to construct a bridge over a wide range of challenging sites which feature limited or restricted access, including those with the following characteristics:

- Deepvalleys
- Deep watercrossings
- Steepslopesorpoorsoilconditions making equipment access difficult
- Environmentally protected speciesor cultural resources beneath the bridge

The reason for this disparity is unclear and it is one of the goals of the proposed work to ascertain the reasons for and attempt to eliminate this potential “knowledge gap” for bridge owners, designers and contractors.

Specifically, the project objective is to provide bridge owners, designers, and contractors with information and understanding about the ILM, including applications and benefits.
Three books have been published in the past which present a very comprehensive investigation of the design and construction of bridges constructed by incrementallaunching.

These references are highly recommended for owners, designers and contractors desiring a thorough knowledge of the ILM. The books also make reference to several bridges that have previously been built by use of theILM.
The detail presented for these bridges, however, is insufficient to provide summary information for this report. A list of the bridges mentioned is provided in Appendix A for future consideration by bridge owners. The three books are listed with a brief bulleted summary of theircontent.

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Incrementally Launched Bridges: Design andConstruction

- Overview ofILM
- Historicaldevelopment
- Evaluation of ILM used for various crossings
- Design criteria and considerations for design Constructionconsiderations

Bridge Launching

- Overview of ILM for prestressed concretebridges
- Evolution of ILM for concretebridges
- History of analyticalknowledge
- Obstacles encountered prior to and duringlaunch
- Details and components for effectively launchingbridges
- A composite, and prestress composite bridges.

Launched Bridges: Prestressed ConcreteBridges Built on the Ground and Launched intotheir FinalPosition

- Detailed analytical and conceptual information pertaining to the following: oDesign
  - o Organization
  - o Economics of construction techniques
  - o Constructionmethods
  - o Launchingtechniques
  - o Additional effects (i.e. thermal, time, etc.)
- Alternate launch methods (i.e., rotation, side translation,etc.)
- Trends and ongoingresearch

The most common launching method in Russia involves using jacks to push the bridge horizontally across piers with special sliding devices on supports to lessen friction forces. The pushing device is made up of hydraulic jacks and clamps.

The superstructure is first clamped with a set of steel plates. The jacks then launch the bridge with the help of the clamps.

When the cycle is complete, the clamps are released and re-attached to their initial position. One cycle can push the bridge

up to 1.5 m and takes about 10–20 minutes. Sliding devices reduce the friction forces on the steel bridge as it crosses the supports. Sliding devices are made up of common elastomeric bearings, a stainless steel sheet covering, and sliding panels of plywood sheathed with PTFE antifriction material.

The plywood sliding panels are placed between the steel girder of the bridge and the stainless steel sheet. The bearings are used to distribute stresses evenly across the girder.

The Easton Bridge is a three-span, steel girder bridge that crosses a deep ravine in the Mountains of tamilnadu (1998). The bridge spans a distance of 255 feet and serves as a recreational trail. Boss Construction Co. was hired to erect this bridge in place of a trestle that had been swept away by floods. The bridge was supposed to be erected from either side of the ravine but limited crane access on one side prompted the contractor to use a launching method.

The bridge was mounted on two dollies at the western side of the ravine and pushed over rollers on the first pier to the second pier 195 feet away. A crane then dragged the bridge the last 60 feet to the eastern abutment. Push-pull jacks were used to counter deflection of the bridge as it was launched across the ravine. The jacks, located on the piers, raise the bridge high enough to pass over thepiers.

The construction, originally planned for one day, had to be delayed over a weekend. The bridge was pushed halfway across and stabilized on Friday. The following Monday, construction was finished.

Bridge launching was a successful method for a bridge replacement in the decided to relieve congestion near the Station by removing an older bridge and constructing a new wider bridge over the continuously running traintracks.

A bridge launching method was chosen because it would necessitate the least amount of rail line closures. The new steel girder bridge with composite concrete deck spans a distance of 180 m. Construction began by raising the old bridge on four temporary

jacking towers. The bridge was then launched underneath the old bridge.
After completion, the old bridge was lowered and removed. Varying girder depths along the length of the bridge were an issue as the bridge was launched across the piers. Jack levels were adjusted continuously during the launch to compensate for these irregularities.

The bridge crosses the valley of a height of about 25 m. Its superstructure is comprised of two parallel box girders with a 37.77-m wide deck slab on top. With a total length of 420 m forming 8 spans, it is uniformly curved with a radius of 2,000m.

During the launching operation, specially designed bearings consisting of a block of concrete covered with a stressed sheet of chrome steel were installed on all permanent and temporary piers.

Steel/neoprene/Teflon plates were placed between the leading box girder and these bearings to keep the friction to a minimum. The friction recorded at each launching operation was approximately five percent, which was close to the assumption made during thedesign.

Survey of State DOT Bridge Engineers Survey Process

An electronic survey was developed with the original intent to contact the chief bridge engineers of the 50 state DOTs. In order to ensure a wider representation of the bridge community, the survey was in fact directed to each member of the AASHTO Subcommittee on Bridges and Structures.
The subcommittee comprises 116 individuals from a wide variety of owner agencies, including the following:

- 50 state Departments of Transportation (1 to 3 committee members perstate)
- Federal HighwayAdministration
- American Association of State Highway and TransportationOfficials
- Canadian provincial transportation agencies (5members)
- Other bridge owner agencies (e.g. turnpike authorities, US Army Corps of Engineers,etc.)

The survey was developed, distributed and collected through an online survey service entitled SurveyMonkey.com, allows respondents to access an online version of the survey, respond to each question, and submit their answers via an easy-to-use form. In addition, the survey data can be continually analyzed by the research team to monitor trends.
Each response can be traced back to the email address of a respondent. Follow-up reminder notes were sent to each survey recipient who did not respondinitially.

A Overall, a total of 40 survey responses were recorded by the online system, for a response rate of 34 percent, which compares reasonably with past surveys performed by the research team.

A presentation of data and discussion of responses from selected survey topic questions are briefly summarized in this section.
The complete survey is provided in Appendix B of this draft report. In the data tables associated with some questions presented in this section, those responses that received more than 50% of the total are highlighted in red.
For those questions where a respondent was asked to evaluate the significance or usefulness of various alternatives.

Selected Survey Topic 1: Familiarity with ILM
This question focused on the personal familiarity of the engineer with the incremental launching method for bridge construction. In addition to

asking that question, the engineer was asked how they first learned about incremental launching.

The response to the first question resulted in 55% stating they were personally NOT familiar with incremental launching.

Only 40 replies were received for this question, and it is very possible that a much higher percentage of surveyed engineers are similarly NOT familiar with launching as a construction practice.

Regarding the question about how the respondents found out about incremental launching, the majority (33%) indicated that bearing.

It is important that patch loading conference presentation was how they were exposed to the topic, with 11% indicating a technical journal article was the source of their information.

Trade publications, books and “other” comprised the other responses. It was interesting that 0% responded to the medium of documentary video/DVD as a source of information.

This response is noteworthy because the Iowa Department of Transportation created a documentary video following the completion of the US 20 Iowa River Bridge in 2003. The project involved the incremental launching of a steel plate girder bridge superstructure.

The video was mailed to all state DOTs and FHWA division offices. However, upon discussion with some respondents, unclear wording of the question was found to be a possible reason why they did not indicate the video as a source of information. The video includes information associated with construction and monitoring of the launched bridge.

Based on the response to the questions above, it appears that technical information regarding incremental launching has not spread widely. One possible reason for the lack of technical literature on this topic is that the designers and contractors are not very interested in sharing information, although it is fair to state that publication by these two groups is usually not a highpriority.

An important issue pertaining to launched steel girders is the load carrying capacity due to concentrated forces. The load on a launched girder is unique because in addition to a bending moment, a traveling concentrated load exists, which is applied by the temporary rollerbearing.

The concentrated load, also called a patch load, is transferred from the bottom flange of the girder into the web. The support reaction “moves” along the girder each time the launched segment passes over a pier does not introduce residual deformation or damage to the web plate. The effects of patch loading must be understood in order to know what web thicknesses are required. Even small increases in web thickness can add great weight and extra costs.

STRATEGIC PLAN FOR INCREASINGUSE OF INCREMENTAL LAUNCHINGMETHOD

The implementation of research results, no matter how comprehensive and practical, is perhaps the most difficult part of any researchproject.

In order to increase the application of an innovative construction process such as the ILM, the entire bridge community must be engaged for a variety of reasons.

In order to construct a bridge over a challenging obstacle, the bridge owner must be committed to the additional risk and expense that a new or untested process entails.

Bridge designers must begin to consider the construction method early in the design process and understand the additional analysis that will be required.

Contractors, and their erection engineers, must be willing to work cooperatively with the design team to solve the problems that almost inevitably arise with a new process and design a launching system which is well-suited to existing or readily available specialty equipment such as jacks and rollers.

A recommended strategic plan to promote the wider use of the ILM consists of a number of approaches that, in concert, would be expected to increase the exposure of this bridge construction technology to a wider audience. It is recognized that incremental launching is not the ideal construction method for every bridge project.

However, it is thought that a wider understanding of the applicability and potential benefits would allow potential owners, designers and contractors to make a well- informed decision as to its use for their upcomingprojects.

The elements of the recommended strategic plan are as follows:

- Organize an expert group of owners, designers and contractors with personal experience with bridge launching who would be willing to advise owners regarding the value and applicability of the launching method to their particularproject.

• This program might be patterned after the ongoing FHWA Accelerated Construction Technology Transfer (ACTT) program which arranges a group of qualified experts in a wide-range of disciplines to present a multi-day workshop for a particularproject.

• The workshop is used to promote brainstorming and develop critical recommendations for accelerated construction projects around thecounty.

• Establish a series of cooperative agreements with bridge-related technical organizations associations such as NSBA, PCI, ASBI and other similar groups to provide information and encourage the writing of technical papers and presentations at future national/regionalmeetings.

Encourage the publication of practical case study-type articles in trade publications such as Civil Engineering, Engineering News Record and Concrete International.
One potential location for wide- spread exposure to the industry is the new PCI Aspire magazine which is distributed free of charge to the target audience of bridge owners, designers and contractors. It should be noted that an article has just been published in the October 2007 issue of Concrete International entitled “Launch and Shift of the Bridge”.

This article provides a detailed case study of a twin-concrete box girder bridge in which the first girder was launched and then slid transversely to permit the subsequent launch of a second parallel girder using the same equipment.

In the past few months, a number of presentations have been made at regionaland national conferences to address the growing interest in using the incremental launching method. Each of these presentations was well- attended and generated much

The superstructure was launched in segments of 25 m from pier to pier using a custom-made jacking frame. Two jacks were used to launch the bridge away from the frame.

These segments were cast in two concrete pours and launched on weekly cycles. Permanent bearings, with a steel plate and elastomeric bearings placed between the bottom flange and the permanent bearings, were used forlaunching.

The use the permanent bearings for launching eliminated the use of temporary bearings normally used in incremental launching operation. ‘Spray-on’ silicone grease was used to keep the friction between thesuperstructure.

Following construction, three types of cracks were found in the box girder: punching shear cracks, flexural cracks and cracks adjacent to the cast-in bearing plates. The punching shear cracks were caused by the concentrated force from the permanent bearings on the box girder.

The flexural cracks caused by eccentricity of the bearing reactions on the box girder were found on the top flange of the box girder. Cracks also formed near the cast-in bearing plates, seen in Fig. 3d, because the contractor welded the launch blocks to the cast- in plates instead of bolting them together. The thermal expansion and contraction of the metal caused the cracks to form.

Lessons were learned from the project that the launch bearings should be positioned as close to the box girder webs as possible since eccentricities between the bearings and web cause flexural cracking during the launch. This may be difficult to accomplish when using permanent bearings. The experience also suggested that the launch bearing contact area of the girder be stiffened if permanent bearings are used for launching. In addition, it is critical to meet the construction tolerances on the box girder profile since small irregularities can cause uneven stressdistribution.

III. CONCLUSION

Construction management basically is a tool to complete the project effectively within fixed amount but in less time. Manager should have knowledge sequence of all the activities. Decision making for both sides the contractor and the client needs to be fast and time bound otherwise the project will get delayed which will have cost over run. Control in form of reviewing monitoring has a catalyst effect to boost the progress.

• All bridges held generally the same amount of weight. The arch bridges held a little more than the other bridges. They were in the 1400-1500gram range. The other bridges were in the 1000-1200 gramrange.

• The bridges would not stand up on their own, so a support at each end had to be constructed. Balancing the weights on the bridges required patience .Clamps were used to hold the bridges during gluning

• The bridges supported different amounts of weight because each type has different construction. The arch bridges supported the most weight beause of the great natural strength of the arch. The pier bridges supported the least weight because the supporting piers broke duringconstruction.

Bridge engineering is based on concepts that are introduced. When designing a bridge it needs to be established what functions it needs to fulfill. The four main functions – structural safety, serviceability, economy and ecology, and aesthetics – are introduced and their interrelationships are explained. Furthermore it is important to realize that the concept of 'failure' also relates to the four main functions, i.e. a bridge project may be considered an unsuccessful undertaking if e.g. the bridge is structurally sound but shows excessive deflections that decrease the riding comfort. Bridge designers need to keep this concept in mind when beginning workon a new project. The design process is usually subdivided into several steps, beginning with conceptual design. Compiling the requirements for the new bridge and any important characteristics of its planned site forms the base for any design. The further design process will comprise many drafts and revisions until a feasible design has been produced. Constructability issues need to be included from a very early stage on to ensure that the bridge can be built in a safe and economical manner. In the beginning the dimensions of structural members will be chosen mostly based on the designer's experience, in later stages engineering software is then employed to compare alternatives and optimize member dimensions. Finally, complete analytical calculations for all important construction stages and detailed shop drawings will be produced.

As mentioned above, aesthetics is considered one of the four main functions of bridges. Several so-called aesthetic values of bridge structures are identified. These are character and function, proportions and harmony, complexity and order, color and texture, and environmental scale. It is the composition of all of these values together that makes a bridge become accepted by the general public as an appealing structure. With respect to the bridge site itself, several influencing factors are identified. Soil conditions, topography, the river crossing, protection of the environment, and the local climate are the main environmental influences. Furthermore, technical factors such as bridge type and erection method, labor-related factors, and the particular needs of the owner need to be considered by thedesigner.

Considering especially Balanced Cantilever Construction, a variety of construction loads needs to be considered,such as weight of erection equipment, e.g. form travelers with newly cast segments, imbalance from differences in erection of new segments at the tips of both cantilever arms, materials being stored on the superstructure, wind, and thermal gradients. Additional stresses can be induced in the structure through e.g. temporary supports and jacking forces from alignment corrections. As outlined before, consideration of all construction stages with their respective geometry and boundary conditions, structural details, time-dependent material properties, and construction loads is a key factor to adequately analyze the structure and design against failures. Examples of bridgefailures due to improper consideration of construction loads illustrate the importance of this matter.

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