DESIGN OF LONG SPAN BRIDGES

A Critical Review

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Abstract : Bridges form a vital part of local and world transport favoring world trade and economics via Globalization. However, with changing trends, more and more advances have come up pertaining to bridge design for an enhanced performance and improved aesthetics. For an environmental condition favoring more than one system of construction of bridges, it sometimes becomes difficult to start to plan and design a particular type of bridge before analyzing the alternatives. Hence, through our project we provide a background for analysis between two chosen types, that is, Prestressed Concrete Bridges & Plate Girder Bridges. Both the bridges will be designed on MIDAS software, the latest technological advancement in the bridge design till date. Based on the design, further steps if planning, drawing preparations & estimation can be done. This thereby saves huge portion of finance and increases prospectus of salability based on firm decisions of the type of construction. Through this paper, we aim at providing a critical review of the works and researches done in this as well as the related domains.

***IndexTerms* – Bridges, Pre-Stressed Concrete, Plate Girder, MIDAS**

I. INTRODUCTION

Bridges have an ancient significance in enhancing trade & commerce. They initially were built based on theories during the Mesopotamia civilization. The first bridge possibly was constructed in Ancient Greece dating as old as 13th Century BC.

Bridge development started from Arches later moving up to cement temporarily. More and more ideas bought bamboos in the business. They were started being used for commercial as well as military applications. They proved to be very vital for defense operations for countries like India. By the time of Industrial Revolution, timber, ropes and iron bridges came into existence providing some significant breakthroughs.

Modern Infrastructure has permitted more and more development in this sector with Prestressed, Girders, RC boxes being some widely used prominent bridge types. This, along with the major breakthrough of mingling technology and Civil Engineering has been a proven tool of easier and faster development of bridge infrastructure around the world.

Bridges can be classified based on various aspects such as :

•Based on type of superstructure – Arch Bridges, Girder Bridges, Truss Bridges, Suspension Bridges, Cable Stayed Bridges.
•Based on type of materials – Timber Bridges, Masonry Bridges, Steel Bridges, RCC Bridges, Prestressed Concrete Bridges.
•Based on type of span – Culvert Bridges, Minor Bridges, Major Bridges, Long Span Bridges.
•Based on type of supports – Simply Supported Bridges, Continuous Bridges, Continuous Bridges.

Figure 1 : Oldest known bridge built by mankind

II. TECHNOLOGY & BRIDGES

In countries like India where population density as well as the corresponding trade and travel are very high, it becomes vital to build flyovers and Bridges for smooth road transport. They also form a significant part of Indian Infrastructure. They also promote peace through international connectivity thereby shortening the gaps between different local cultures.

With these ideal benefits of bridges, it becomes important to scope the improvements in bridge design with passage of time. Various software programs like STAAD.Pro, ETABS, MIDAS, etc. have given proven results with much complex problem-solving techniques. These help in building economic designs for Bridges and thus create a stable profile of Indian Infrastructure.

Although there is still much more need of development with researches, the present advancement has given a promising future for bridge designs. The software programs have been made compliant to the standard requirement of materials and Limit States and also they have been made user friendly for beginners such that they can inculcate faster learning leaving no stone unturned in more and more collection of know-hows from raw minds. It becomes a necessity to build a prolific design with optimum value so that

common people can use it without having to pay more for returns. With proper analysis firm decisions can be made between options without going out of way from the Standard Codes of Practice (e.g. ISC) prescribed by ministries (e.g. MORTH) of regulations.

Excel sheets prove yet another convenient method of performing problematic calculations and giving instant results for effective feedbacks to site requirements. They provide organized detailing to the structure with almost all parts being capable of getting designed and analyzed by it.

With growing population, however, it also becomes necessary to develop environmentally friendly structures with the above-mentioned qualities. Biomimicry can lay foundations for energy, waste and material efficient bridge infrastructures (e.g. Ant Bridges)

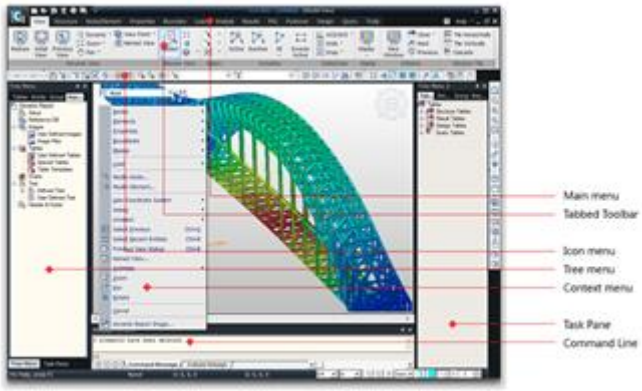

Figure 2: Bridge Design using MIDAS

III. Need of the Study

The basis of this project is created by the various options that have been laid down over the years for the engineers and consultants to choose from. It must be studied carefully whether the chosen design will create any risks during its design life. Any faults in the design or type chosen can lead to fatal issues. Hence, for a large-scale infrastructure like bridge, it becomes highly important that precise and detailed information about each alternative must be prepared.

After proper preparation, the next step should be surveys. On site surveys or on paper legality checks are very important for initiating any project, let alone bridges. The surveys must decide what kind of materials may suit the environmental conditions, the availability of materials and labor and the secondary stipulations of the investors.

After deciding the type of bridges that may suit the site, proper analysis is required so that financial loss due to wrong interpretations are kept minimal. The basic modus operandi to be followed is to check the safety of each type through the Limit States.

IV. Literature Review

The use plate girder other than rolled beam sections gives the designer the freedom to select the most economical girder for the structure. Girder bridges are either truss girders or box girder. Plate girder bridges are commonly used for river crossings and curved interchange ramps. The span lengths generally ranges from 150 to 300 feet .In long span steel plate girder bridges , special attention should be given to the use of lateral bracing to reduce wind load deflection during construction. The repetitive use of flange and web thicknesses can lead to time and monetary efficiencies in fabrication and construction. Web plate ,flange cover plate , flange angles with or without flange cover plate , stiffeners and splices are the elements of plate girder While designing a plate girder to resist the given bending moment ,it is desirable to maximize the lever arm of the internal flange forces so that the material required for flanges is minimized. When the moment resisting capacity of the plate girder is to be increased ,flange cover plates are provided over the flange angles. The flexural strength of the plate girder is based on the tension flange yielding or compression flange buckling. The plate girder web will be subjected to the combination of the shearing and bending stresses. In steel building construction when the web of a plate girder acting alone proves inadequate ,stiffeners should be provided. Load carrying web stiffener are provided where compressive forces applied through a flange exceed the buckling strength of the unstiffened web. Bearing stiffener are provided to transfer concentrated loads on the girder and heavy reactions at supports to the full depth of the web.

The Prestressed Concrete sections have tendons provided to resist the additional stresses developed. This is done by tensioning the steel cables before applying loads so that they have enough strength to cope with higher magnitudes of external stresses. The tendons are anchored at the end (or block section) so that they can transfer the force to concrete thereby creating extra resistance to external loadings. They may be of two types: 1. Pretensioning & 2. Posttensioning. They are various methods of design, the widely used being Frysinnet System. They have certain losses to be taken into account for least risks.

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Figure 3: Typical Prestressed Bridge Section

IV. RESEARCHES

4.1 International Research

F. Leonhardt (1965) developed methods of casting in place. He gave the merits of continuous long span bridges. Methods of Coupling of tendons, Free cantilevering method , Prefabrication of Total of Total span length girders, Prefabrication with Transversely Cut Units have been elaborated in detail. Designs for Indus bridge, Traun bridge, Ager bridge elaborated.

Clifford L. Freyermuth (1982) considers the most important post tensioning details for long span concrete bridges, including remarks on cable stays. Describes various types of post tensioning anchorages and couplers developed for use in long-span concrete bridges. Illustrations on a number of applications of transverse deck post-tensioning, vertical web post-tensioning and longitudinal post-tensioning.

G. C. Lacey and J. E. Breen (1969) Detailed application of segmental precast box girder construction in achieving long spans in bridge structures. Development of efficient casting techniques to obtain the tolerance required for concrete jointing and for epoxy resin jointing. Detailed elaboration of types of prestressing systems, jointing techniques and erection methods that have been successfully applied in long span bridges. Design and construction procedures for long span prestressed concrete bridges.

F. M. Fuller (1956) Development of a set of expressions for the elastic design and ultimate load-carrying capacity of prestressed members in both statically determinate and indeterminate structures. Use of these expressions in the analysis of continuous beams, portal frames, and bridge decks in the light of the results of experimental work. Aspects of research on the effects of friction between prestressing tendons and their ducts in post-tensioned members.

Arkadiusz Mordak, Zbigniew (2016) Experimental research conducted on post-tensioned pre-stressed concrere road bridge situated over water plant of water reservoir dynamic field load tests in Topola village (Poland). Dynamjc load considered through threshold and breaking at midspan.

Christian Menn (1986) Design for safety and Serviceability, calculation of sectional forces due to Loads, Prestressing and Restrained deformations of prestressed concrete bridges. Detailing of reinforcement, Anchorages and splicing of reinforcement. Methods of prestressing, post-tensioning systems, analysis of prestressed cross-sections. Analysis and design of bridge superstructure.

Helder Sousa, Luís Oliveira Santos (2016) of long-term performance of prestressed concrete bridges. Post-tensioning prestressing systems. Materials for prestressed concrete. Design of post-tensioned concrete slab bridge deck. Creep and shrinkage effects.

Nurafiq Asli, Banderul Hisham Ahmad : Exploration of the process of analysis and design of continuous prestressed concrete bridges based on construction stages on site. Analysis of loadings acted on continuous bridges to determine the bending moment of the bridge. Bending moment value due to self-weight obtained from the first construction stages is used to design the prestress force and number of tendons required.

Dimitar Dimitrov Elaboration of the basics of Prestressed concrete design. Application of pre-tensioning and post-tensioning in structures. Design of prestressed concrete bridges. Design of bridge substructure. Application of prestress in the design of bridges.

N. R. Hewson (2008) Provides coverage on all the aspects of the design and construction of prestressed concrete bridges, from fundamentals of prestressing and the equipment used, to insights into the problems that can occur and how they have been dealt with in different projects. Both pretensioning and post-tensioning are included as well as pre cast and in situ construction.

R. G. Oesterle, A. F. Elremaily (2009) Documentation of results of study of precast, prestressed, concrete bridges. Research was conducted to develop guidelines for design and construction and to address issues and provide guidelines as to how to handle these issues. Practicality of existing practices assessed.

R. H. Fry (1914) successful design and construction of long span bridges. Elaboration of the process of design of substructure and superstructure. Practical details dealt with at a greater length rather than purely theoretical considerations. Detailed elaboration on the design of superstructure of long span bridges.

Franklin B. Angomas (2009) Investigation of the accuracy of prestress loss prediction methods. Study of behaviour of prestressed concrete bridges under various load conditions. Study of the loss in prestress and deflection taking place in prestressed concrete bridge.

Wenjie Guo, Ligie Wu (2014) Optimization of prestress reinforcement design in large span prestressed concrete bridges. Methods of reduction of long term deflection of large-span prestressed concrete bridges. Based on elasticity assumptions an optimum prestressed tendon arrangement is derived.

S.Rana & R.Ahsan,S.N.Ghani designed the prestressed concrete I-girder bridge by using optimization algorithm in order to reduce the total cost of the bridge design process. The design constraints were considered based on AASHTO Standard Specifications. This techniques transform the conventional design process into a systematic procedure which gives the best design in terms of specified designer figure of merit.

Rohit Khobaragade,P.D.Ramteke(2016) presented experimental procedure on the steel plate girder with bearing stiffeners and with alternate intermediate stiffener test was performed to study different modes of failure and to calculate the load capacities of the girder. It was found that when plate girder with bearing stiffener is subjected to load, local buckling with minimum distortion in cross section is observed and when girder with bearing stiffener and alternate intermediate stiffener is subjected to transverse load ,buckling of whole section in S-shape is observed.

Nabeel A Jasim ,Fadhil A. Jasim(2016) studied geometric dimensions of plate girder which minimize the total weight and satisfied the design consideration. Also the efficiency of different optimization method were studied. It was found the plate girders weight depends majorly on the flange weight which was approximately0.6 of the total weight and web weight is approximately 0.3 times of the total weight .There is very small effect of stiffener on the weight of girder.

Pawan Patidar, Sunil Harne (2017) presented parametric study of plate girder bridge .It was found that at constant thickness of web ,area of flange varies as per the variation of span .From the software analysis they concluded that if span is kept constant and web thickness varies in increasing order the stress, bending moment and shear force increases while deflection decreases.

Gaya K Vinod ,Manju P M (2016) analysed the buckling of plate girder with rectangular corrugated web. The objective of the project was to compare the buckling strength of corrugated web plate girders with different corrugation parameters. It was found that with decrease in corrugation width buckling strength increases & also found that corrugated web plate girder is much better than plane web plate girder.

Aamod Garg (2016) presented the parametric study of plate girder with variations in loading and span . The paper laid out the general specification of the design of plate girder which can be used at several junctures.

Richard P. Knight (1983) presented features of economical steel plate girder bridges and some guidelines. It was found that load factor design is more economical than working stress design and also longitudinally stiffened designs should not be considered for span less than 91.5 m.

Parvathy Krishna Kumar (2018) presented the design of plate girders for deck type railway bridges .It was found that if the construction depth is not critical ,then deck type bridge ,is the best solution, in which case bracing resist the compression flange against lateral buckling.

Konrad Basler & Bruno Thurlimann (1960) presented this report to investigate the carrying capacity of plate girders. In this paper theoretical consideration regarding the static strength of girder in bending and shear is presented.
Brandon Chavel &Lance Peterman presented the paper which discussed the challenges faced during the design and construction of long span I -girder bridges. They used 3D finite element model for the bridge design to capture all component demands.

Cynthia J.Zahn(1987) presented the design of plate girder using LRFD .It was found that LRFD is very similar to the ASD method .This design help to demonstrate graphically how the applicable specifications section interact and accelerate the familiarization process for the first time users.

4.2 National Research

Prof. S. R. Satish Kumar and Prof. A. R. Santha Kumar from NPTEL gave brief ideas about a complete design of a plate girder bridge. Modern as well as conventional techniques have been discussed.

N. Krishna Raju(2009) in his reference book gave the ultimate idea of prestressed concrete and their applications. He has also illustrated the basic format of consideration while following PC bridge design with AASHTO recommendations in pure view.

Dr.Ramchandra & Virendra Gehlot (2010) in their reference book gave an introduction on loads and stresses for steel bridges, truss girder and plate girder bridges. It also covers the influence line diagrams for stresses in members of surpended span girder.

S.K.Duggal (2014) in his reference book presented the basic principles of plate girder design in a simple manner and also discussed the practical requirements of plate girder.He discussed the ultimate behaviour of plate girder using buckling and post buckling theories.

V. Conclusion

The analytical study of both the types of bridges suggests that even though Pre-stressed bridges offer greater advantages over the plate girder bridges under same arbitrary conditions, it has been established that under situations of lighter traffic, mild environmental conditions & relatively insignificant transport, plate girder bridges must be resorted to owing to less design stipulations and thus lesser economy indebted to the tedious design stage.

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