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ANALYSIS AND DESIGN OF FLYOVER SUB-STRUCTURE – A REVIEW

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Abstract: Our project deals with design and analysis and design of Bridge Sub-Structures consists of Pier, Pier cap, Abutment, Pile cap and Pile. Here the structural analysis is carried out by using STAAD Pro V8i software. This paper aims to understand the concepts involved in the analysis and design of PSC bridges subjected to different loadings namely IRC Class A, IRC Class 70R wheeled and tracked, 40T Bogi loading etc. The different codes of design will be used in this paper are IRC 5-2015, IRC 6-2016, IRC 112-2011, IRC 21-2000, SP 013 and SP105-2015.

Keywords: Pre-stressed Concrete, Sub-Structures, STAAD Pro, IRC Codes.

I. INTRODUCTION

Normally, flyovers are constructed over water basins like rivers, but they may also be constructed over a railway line or even beneath the flyover to offer a highway for pedestrians and even automobiles. The flyover is a strategy in today's age of heavy traffic that allows roads to be built over highways to allow vehicles as well as individuals to pass more swiftly. The flyover, also known as an overpass, is a structure that is constructed over an existing road or railway and spans another road or railway. It aids commuters in saving time, whether they are pedestrians or driving vehicles. However, critics of flyovers argue that they waste valuable area by constructing massive pillars on the existing road. However, their advantages exceed their disadvantages since they allow for more efficient and quicker transportation of people and vehicles.

1.1Type of Flyover.

Classification of Flyover according to Form
- Overpass Flyover
- Underpass Flyover

Classification of Flyover according to Material
- Composite Flyover
- Steel Flyover
- Concrete Flyover

Flyover is a structure that is constructed to provide passage over the natural obstacles without closing the way below it. The obstacles may be rivers, canals, valleys, or roads. The development of the country is based on the infrastructure available in the country. Highways are the major part of infrastructure allowing the flow of human beings, goods, and vehicles. T-beam flyovers are most widely used for the flyovers constructed on highways. IRC codes are developed and updated from time to time based on the research work carried out all over the world. There are different types of designs that serve a particular purpose and apply to various circumstances. The design of the flyover mainly depends: on the purpose of the flyover, the location where the flyover is constructed, the materials used for construction, and the capitals available. The flyover consists of mainly two parts, superstructure, and substructure. The Superstructure consists of a longitudinal girder, cross girder, deck slab, cantilever portion, footpath handrails, and wearing coat. Substructure consists of pier, pier cap, abutment, foundation. The flyover superstructure and other components of the flyover are subjected to a set of loading conditions for which the structure must withstand. The design of the flyover is based on the loadings which may vary depending on the duration of load acting, direction of action, type of deformation, and nature of structural behaviour. To form a consistent basis for design, the Indian road congress (IRC) has developed a set of standard loading conditions, which are taken into account while designing a flyover. account while designing a flyover. Most common types of construction pertaining to substructures are abutment, pier, and foundation. Where appropriate, piers and abutments shall be designed to withstand dead load, erection loads, live loads on the roadway, wind loads on the superstructure, forces due to stream currents, floating ice and drift, temperature and shrinkage effects, lateral earth and water pressures, scour and collision, and earthquake loading.

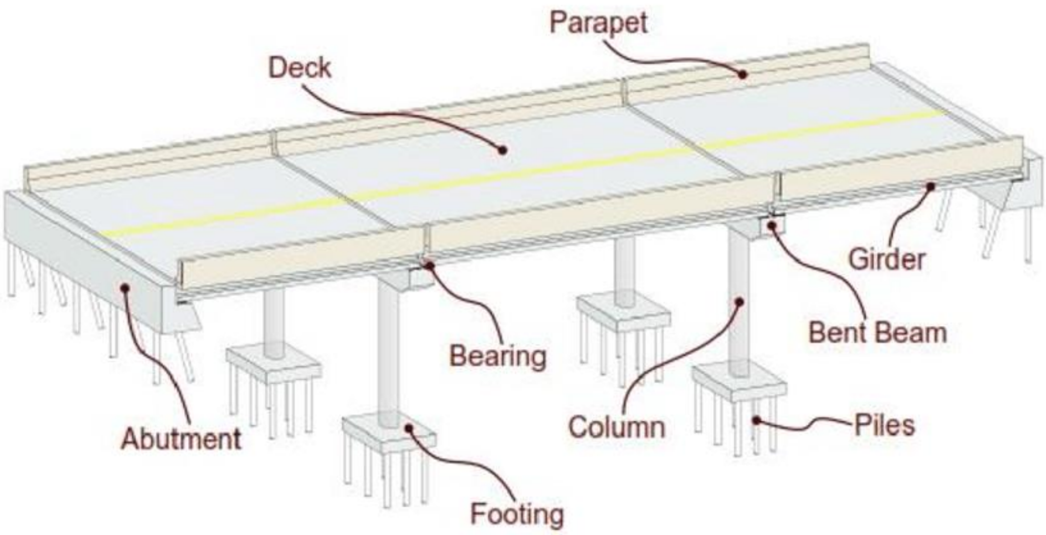

Figure: Components of Flyover

II. LITERATURE REVIEW

Chun S. Cai, Mohsen Shahawy, and Robert J. Peterman worked on "Effect Of Diaphragms On Load Distribution Of Prestressed Concrete Bridges" Load testing results for six prestressed concrete bridges were used to evaluate analytical methodologies. The bridges having different span lengths, number of lanes, and skew angles were analysed by finite element method. Bridge performance was dependent on a large number of variables, and simplifications were usually made when creating a model for analytical rating and design Maximum strains and load distribution factors predicted by analyses and AASHTO code specifications were compared with those from measurements. The results indicated that, by including the full stiffness of intermediate diaphragms in the finite element models significantly reduces the maximum girder strains, also prestressing the diaphragm may increase its stiffness to full stiffness which may significantly reduce the load distribution factors(LDF) and maximum strain and increase of the skew angle may reduce maximum strain and load distribution factors for the cases without intermediate Diaphragms.

By James H. Loper, Eugene L. Marquis, Members, ASCE, and Edward J. Rhomberg, Fellow, ASCE carried out the study on "Precast Prestressed Long-span Bridges" This study shows that in the United States, precast prestressed members have gained wide acceptance in bridge design over recent years. This acceptance was partly due to prestressed concrete's economic characteristics. Simple reinforced concrete required fewer man-hours than does prestressed concrete. This was due to extra labour needed for fabrication, placing, and anchoring cables. For bridges with span lengths above 30 m, prestressed beams were the more economical choice. The total economy of the structure was dependent on the cost of maintenance, the man-hours required for construction, the cost of materials used, and the dead load of the structure. Ultimately, it was the job of the engineer to consider each economical facet and design a safe structure which can perform as intended.

Edward H. Power, et al carried out the study on "Experimental evaluation of high-performance sliding Surfaces for bridge bearings" This document covers research and proof-of-concept testing to investigate the feasibility of increasing bearing service life by using alternative high-performing materials instead of typical plain PTFE in bearings that use sliding surfaces for movement. This paper is about the Material wear and coefficient of friction (COF) were examined across a range of parameters in an experimental testing programme. contact pressure, rate of movement, and total movement accumulated UMWP and GFR-PTFE both had significantly higher wear rates. When subjected to initial testing with high contact pressure (20.7MPa or 3,000psi) and high rate of change, it outperforms ordinary PTFE. Movement was faster (63.5 cm/min or 25 in./min), but COFs were higher. Under the initial testing circumstances, plain PTFE was demonstrated to wear at a rapid pace, resulting in significant thickness loss in less than 2 mi of accumulated sliding length. In initial tests over about 8 mi of accumulated sliding length, glass-filled reinforced PTFE showed the best wear resistance with no material thickness loss. Initial thickness drop in ultrahigh-molecular-weight polyethylene was seen, which could have been due to material compressibility. Both contact pressure (P) and the rate of movement (V) were shown to be contributing elements in the results. Wear on the sliding surface The study also revealed a direct

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association between the rate of material wear and PTFE and GFR-PTFE. Greater levels of PV resulted in increased rates of material wear, as did the factor of P times V (PV). Furthermore, wear rates were fairly homogeneous at these PV values. PV limits or thresholds at which the rate of material wear was very low or almost zero were also found.
Jin Cheng studied on "Serviceability Reliability Analysis of Prestressed Concrete Bridges" This study exhibited that the ANN-RSM allows one to obtain an accurate reliability index and simultaneously to limit the number of performance runs needed to fit the response surface. An efficient, accurate and robust algorithm was proposed to estimate the serviceability reliability of prestressed concrete bridges. The proposed algorithm integrated the advantages of the ANN method, first order reliability method (FORM) and the importance sampling updating method. In the proposed method, an ANN model was used to approximate the limit state function so that the number of required deterministic response analyses can be dramatically reduced. Although emphasis in this study was placed on the serviceability reliability of prestressed concrete bridges, the proposed algorithm offers immediate applications to other bridges structures as well as other probabilistic problems, such as those involved in structural risk as an issue.

Tae-Hoon Kim Studied on "Comparison of Totally Prefabricated Bridge Substructure Designed According to Korea Highway Bridge Design (KHBD) and AASHTO-LRFD" The goal of this research was to compare the design of completely prefabricated bridge substructure systems. Prefabricated bridge substructure systems are a new and versatile substructure design option that can provide a number of advantages. The technology can reduce the amount of work that needs to be done on a construction site, resulting in shorter construction times. Korea Highway Bridge Code (KHBD) techniques and load and resistance factor design are used to design the prefabricated bridge substructures (AASHTO-LRFD). The KHBD with DB-24 and DL-24 live loads was used in the design. This research compares and contrasts the KHBD (2005) and AASHTO-LRFD (2007) design methods for completely prefabricated bridge substructure systems. For the examination of reinforced concrete structures, the computer programme Reinforced Concrete Analysis in Higher Evaluation System Technology was employed. Based on the finite element method, a bonded tendon element is used to describe the interaction between the tendon and the concrete of a prestressed concrete part. In order to forecast the inelastic behaviours of segmental joints, a joint element is used. This research compares the design of completely prefabricated bridge substructures and offers conclusions and design recommendations based on the findings.

Xia-Chun Chen, Zhen-Hu Li, Francis T. K. Au and Rui-Juan Jiang studied on "Flexural Vibration Of Prestressed Concrete Bridges With Corrugated Steel Webs" The two-dimensional analytical model was developed for the bridge based on few assumptions: (a) The shear deformation of the flanges and the flexural rigidity of the web were negligible; (b) The beam was incompressible vertically; (c) Materials were isotropic and elastic; (d) The beam was prestressed so that tensile stresses induced by the live loads can be resisted; This study extends the sandwich beam theory to predict the flexural dynamic properties of PC bridges with corrugated steel webs taking into account the effect of diaphragms and external tendons. The diaphragms had significant effect on the flexural natural frequencies and mode shapes only for shear rigidity values below a certain limit, namely, for bridges with short spans and/or lower ratios of section shear rigidity to flange local bending rigidity. For bridges with shear rigidity above a certain limit, namely, for bridges with long spans and/or higher ratios of section shear rigidity to flange local bending rigidity, the flexural natural frequencies and mode shapes obtained from the sandwich beam model and the classical Euler–Bernoulli and Timoshenko models tend to be the same. For bridges with wide flanges where the shear lag effect may be present, the use of effective flange width in stiffness calculation improves the accuracy.

Abdul Rashid, P. Veerabhadra Rao carried "Analysis Of Girder Bridge With IRC And IRS Loadings – A Comparative Study" They made a comparative study on both IRC & IRS loadings for the design of bridges using STAAD Pro and MIDAS software. They used RCC members for IRC loadings and PSC members for IRS loadings. This study infers that the load per meter run of IRS loadings was increased by 210% compared to IRC. The Bending Moment due to IRS 25T Loading-2008 load combinations increased on an average of 4.6 times to the Bending Moment due to the IRC loading and Shear force due to IRS 25T Loading-2008 load combinations increased on an average of 3.2 times to the Shear force due to IRC load.

Dr.Laju Kottalil1, Drisya P.V, Fawas V, Jibin Joseph, Renjitha Raju carried out "Analysis And Design Of A Bridge At Bhoothathankettu Barrage" This paper discussed a study about using 0.7 inch prestressing strands in bridge girders fabrication. The study had two phases. An analytical phase to calculate the possible increase in flexural capacities of I-girders when 0.7 inch strands were used, and the effect of girder and deck compressive strengths on composite girder-deck capacity, and a case study to comp were bridge panel design constructed using 0.7 inch and 0.6 inch diameter strands. In this paper they analysed the RCC & PSC beams against the different loading conditions. They studied the analysis of prestressed concrete beams more effective as compared to reinforcement concrete beams in flexure using different loading conditions. The prestressed concrete was better in structural behaviour, durability. Results showed that overall flexural analysis of prestressed concrete beam was very good in all aspect compared to reinforced concrete beam. The conclusions were, the size or dimensions of structural members were reduced, which may increase the clearances or reduce story heights. It permits the use of large spans (greater than 30 m) with shallow members, even when heavy load were encountered. In addition to general advantages, such as excellent fire resistance, low maintenance costs, elegance, high corrosion-resistance, adaptability etc, the prestressed concrete was found to sustain the effects of impact or shock and vibrations. Because of smaller loads due to smaller dimensions being used, there was considerable saving cost of supporting members and foundations.

Vivek Gajera1, V. R. Panchal, Vishal Vadgama carried out "Comparative Study of Seismic Analysis of Pier Supported on Pile as per IRC:6-2017 and IRC SP:114-2018" The study of seismic analysis of reinforced concrete bridge piers according to Indian Road Congress (IRC) guidelines is presented in this work. The "Superstructure" and "Substructure" are the two main structural elements of a bridge. The deck and the supporting girder/truss system below deck make up the superstructure. Abutments, Piers, Portals, and Foundations are all examples of substructure. Abutments/Piers are an important feature of a bridge. As a result, according to seismic design principles, it is required to investigate the seismic behaviour of bridge piers. IRC rules are updated and altered on a regular basis to keep up with technological breakthroughs and subsequent research in Infrastructure domains. One example of such progress is the introduction of the IRC SP:114-2018 standard for earthquake forces in bridges. The seismic analysis of a Reinforced Cement Concrete (RCC) bridge pier is carried out in this study according to the provisions of the current IRC:6-2017 regulation. IRC:6-2017 base shear value is compared to IRC SP:114-2018 seismic provisions, which now supersede IRC:6-2017 seismic regulations. Different span lengths of 25 m, 30 m, and 36 m are employed for analysis. Various pier heights such as 10 m, 20 m, and 30 m are considered to analyse the influence of pier height on earthquake analysis. According to IRC rules, the study is carried out using the Elastic Seismic Acceleration Method, which takes into account different zones and the importance of the bridge. The impact of vertical ground motion is also taken into account in the analysis. According to IRC SP:114-2018, base shear and vertical forces have been significantly enhanced as compared to IRC:6-2017.

Qi Zhang M. Shahria Alam carried "Performance-based seismic design of bridges: a global perspective and critical review of past, present and future directions" Performance based design aims at achieving one or more predicted performance levels after pre-defined hazards. Damage limit state was an important component of performance-based design. Commonly used limit states were serviceability, damage control and collapse prevention. Serviceability means no repair was needed. Damage control indicates the damage was repairable. Collapse prevention implies the damage may not be repairable but collapse has to be avoided. This study concluded that Performance-based design was a promising and sophisticated design methodology that can be applied to both traditional ductile design and innovative damage avoidance design. Damage states of bridge columns were well defined in codes and can be easily checked by designers. When comparing the performance-based design criteria among different codes based on the case study, the Canadian Highway Bridge Design Code (CSA, 2014) was the most stringent code as it does not allow steel yielding for major route bridges under 475-year earthquake loads. Based on the case study, the column axial load capacity decreases significantly when the maximum lateral displacement was equal or greater than three times yielding displacement. Last but not the least, performance-based design was not limited to ductile structures, it applies to damage avoidance structures as well. Performance-based design makes it easier for designers and owners to communicate so that ultimate performance goals may be met without having to follow prescriptive code procedures for traditional buildings. It allows for the creation of new structures that outperform traditional ones.

III.CONCLUSION

- Identify the research gap. Pre-stressed concrete bridges could be widely used for long spans, National highways and State highways with different loading conditions.
- Performance based design is more economical method for designing bridges with predefined hazards.
- From the study it is understood that selecting the components of sub-structure of bridge should be high performing and economical.
- Software analysis gives us much more detailed report about the behaviour of the structure under different loads. However, the economy of the structure may be affected since the software applies the principle of superposition and gives very high values of reactions/forces.

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