International Journal of Advance Research in Science and Engineering
Volume No. 11, Issue No. 05, May 2022
www.ijarse.com
IJARSE
ISSN 2319 - 8354

COMPREHENSIVE STUDY ON CAUSES OF CRACKS AND REMEDIAL MEASURES IN REINFORCED CONCRETE BRIDGE PIERS AND ABUTMENT OF MAJOR BRIDGE

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ABSTRACT

The Useful life of a buried concrete, containment structure for low level nuclear strength may be controlled by the loss of its load-bearing capacity or an increase in permeability. The Latter factor is controlled by the general degradation of the concrete and by the presence of discrete cracks reducing from extremely applied loads or from restraint to normal volume changes. To be able to predict the effects of cracks on permeability, it is necessary to understand the causes and mechanisms of discrete crack formation in reinforced concrete structures. The Objective of this report is to provide an overview of the design and behavior of reinforced concrete members and to discuss the factors affecting the formation of cracks in hardened concrete. The Underlying philosophy of modern reinforced concrete design is presented, and it is shown that it allows for the formation of cracks of controlled widths under service loads. Models for predicting the width of flexural cracks are reviewed. Factors Affecting drying shrinkage cracks and approximate methods for considering them are discussed. An Example is provided to illustrate how to determine whether drying shrinkage cracks will develop under specific conditions. This is followed by a discussion of techniques to predict the number and widths of drying shrinkage cracks. The abutment and piers of a bridge shows different crack patterns when it's subjected to gravity loads and as well as moving loads, for that cracks in abutments and piers will be treats by using injectioning of Epoxy resins, retrofitting techniques etc.

I INTRODUCTION

Bridges in the area are typically composed of short spans with span lengths of approximately 15 m. Bridges are simple spans with expansion joints at each pier and supported on elastomeric bearings with no continuity of the superstructure or any fixity at the intermediate diaphragms. L-shaped abutments are typical for all newer concrete and older masonry bridges. The substructure of most bridges is wall piers supported on shallow foundations with no consideration for ductility. Use of deep foundations is not prevalent, even though liquefaction and lateral spreading is to be expected in the region in a seismic event. Both existing bridges and those under construction suffered extensive damage during the earthquake.

II LITERATURE SURVEY

According to a survey done by McDonald on 52 departments of transportation across North America, more than 100,000 bridges crack early, typically when concrete is 1 month old (McDonald et al., 1995). The cracking of concrete is independent of the age, size, type of superstructure, number and length of spans, and the type of concrete used for construction. Thus, in order to take necessary steps to prevent cracking of concrete bridge s, it is important to study the extent of cracking in these bridges. Although there have been significant advances in the concrete materials, mix procedures, design specifications and construction technologies, bridge cracking continues to be a major problem. In many cases, cracks begin to occur in the early life of the bridge, even before it is open to traffic (Schmitt and Darwin, 1995). Based on the survey by IRC, 42% of the bridge show cracking within the first week of construction of the bridge Cracking in concrete bridge is caused by many factors such as construction practices, concrete mix proportions, material properties, structural design, and loading. Cracking of bridge may lead to corrosion of reinforcing steel, as the cracks allow harmful corrosive agents to enter the bridge , and increases maintenance burden. Reinforcement corrosion can be due to one or the combination of carbonation or chlorine ingress, chemical attack, physical damage due to the freeze-thaw cycle, salt scaling, abrasion, etc (Bajaj, 2013). Also, corrosion of reinforcing steel leads to spalling and loss of cross sectional area for the reinforcing steel, impacting the shear and moment capacity of the bridges. Moreover, the substructure of the bridge is affected due to the entry of moisture and harmful salts through the cracks (Krauss and Rogalla, 1996). Accordingto statistics provided by Yoon et al. in 2000, the cost associated with corrosion of bridge due to cracking in the United States was $150 billion There are indirect costs associated with it, such as those caused by traffic delays and loss of productivity. Furthermore, the replacement and repair of the cracked bridges also adds to the actual money spent on the bridge construction.

Mohammed (2011) studied reinforced concrete members under impact loading and how carbon fiber reinforced polymers could be used to rehabilitate aging structures. The finite element code LS-DYNA was utilized to study the response behavior of vehicle collisions with bridge piers and reinforced concrete beams subjected to impact loads. The Chevy C2500 pickup truck and Ford F800 single-unit truck were used to impact a single hammerhead type pier in the simulations. The impact simulations were validated. Writing examined in pertinence to the goals of the present investigation. There is different investigations done by the scientists on extension wharfs. The examination on adequacy of IRC live burden on scaffold dock is finished by M.G. Kalyanshetti and C. V.Alkunte. A parametric report is done for viability of IRC live burden for different stature of dock and range of scaffold for various state of wharf is considered. Another investigation is done by Premsai T. on scaffold wharf. They have done basic examination and enhancement of extension dock utilizing ANSYS. The investigation ofextension wharf is to know the variety of relocations, stresses, amount of steel and amount of cement. A parametric investigation of solid projection connect is finished by JiminHuan and Carol K. In this a parametric report was directed to broaden the consequences of a test program on a solid indispensable projection (IA) connect in Rochester, MN to other fundamental projection spans with various structure factors including heap type, estimate, introduction, profundity of fixity, and sort ofencompassing soil, fixity of the association between the projection heap top and projection stomach, connect range and length, and size. Seni ALFIO, thought about live loads utilized in expressway connect plan in North America and Western Europe. He had talked about for the most part three points. - Provisions for live burden in U.S, Canada, Great Britain and France. - Quantitative correlation of minutes and responses for various cases. - Qualitative correlation of determinations with respect to theirstraightforwardness and simplicity of utilization. He found that the benefits of stacking from AASHO (American Association of State Highway and Transportation Officials) code and French loadings are near one another in spite of the fact that stacking design are extraordinary. Among all loadings, AASHO and CSA loadings demonstrate the lower esteems. Seni Found a few varieties quantitatively in regards to the accompanying. - For piece connect, contrast is 25% to 40% - For basically upheld shafts, minute changes from 32% to 110% and response shifts from 51% to 148%. - For constant two range braces, positive minutes differ from 20% to 93% and response on center help from 84% to 120%. Europe and North America both are profoundly.

III BRIDGE VISUALIZATION AND CRACKS

The structure which is made upon the river or a gap without closing the way beneath is known as a bridge. it is required for the passage of roadways, railways and carriage way. In the beginning men used the fallen trees or wooden logs for making bridges overthe river or gap.

Components of Bridges

Superstructure:

The part of the bridge on which the loads are directly applied is called the superstructure. slabs. Beam Girders and Trusses are example of the superstructure.

Substructure: The portion of the bridge structure below the level of bearing and above the foundation is called as sub-structure. Piers and Abutments are called sub- structure.

Pier and Abutment Cap: The pier or abutment cap is the block resting over the top of the pier or the abutment. It provides the immediate bearing surface for the support of the superstructure at the pier or abutment location, and disperses the loads from the bearings to the substructure evenly.

Piers: Piers are the structures located at the ends of bridge spans at the intermediate points between the abutments. The function of the pier is two-fold: to transfer the vertical loads to the foundation and to resist all horizontal forces and transverse forces acting on the bridge.

Abutment: An abutment is the substructure which supports one terminus of the superstructure of a bridge and at the same time, laterally supports the embankment which serves as an approach to the bridge.

Bearing: Bearings are provides in bridges to transmit the load from the superstructure to the substructure in such a manner the bearing stresses induced in the substructure are within permissible limits.

Footing/foundation: The part of the bridge which is in direct contact with the earth and transmits all the loads directly to the earth is called the footing/foundation.

Wing wall: Wing walls are provided at both ends of the abutments to retain the earth filling of the approaches. The soil and fill supporting the roadway and approach embankment are retained by wing walls, which can be at right angles to the abutment orsplayed at different angles.

Bed block: A reinforced concrete bed block resting over the top of the piers & abutments is generally provided to evenly distribute the dead and live loads on the pier and abutments.

Superelevation: Super elevation is tilting the roadway to help offset centrifugalforces developed as the vehicle goes around a curve. Along with friction it keeps a vehicle from going off the road. Super elevation is required on curved path.

Camber: Camber is the cross slope provided to the road surface in the transverse direction to drain off the rain water from the road surface. Cracking in reinforced concrete structures of various types can be divided into two main groups:

1 - Non-structural cracks2 **Structural cracks**

In early-stage charisma and charisma into the fresh concrete is plastic and the mold is of concrete road Can be pointed out that the following three categories:

1) Shrinkage cracking
2) Cracking due to reinforcement corrosion
3) Cracking due to drying during the curing

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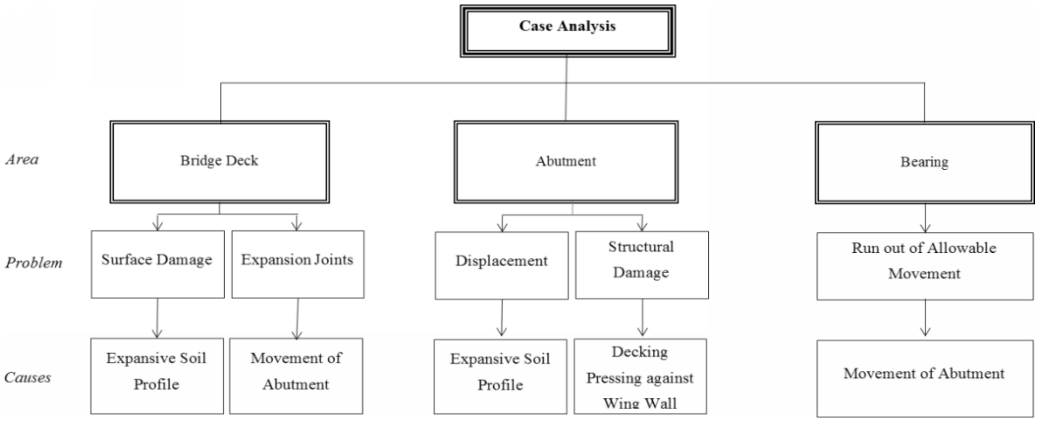
ISSN 2319 - 8354

Inspection of bridge and approaches



CONSTRUCTION CONTROLS AND LAYOUT

Horizontal Controls:

To ensure the bridge lines up correctly with the approach roadways, the initial surveyand layout establishes one or more centerlines to guide the construction of the bridge.

The important centerlines to check include:

1. The centerline of construction (sometimes referred to as baseline of construction orsurvey line)
2. The centerline of structure
3. The centerline of roadway
4. The centerline of bearing (may also be called centerline of Pier)

Vertical Controls:

- To maintain the proper grade of a bridge and the elevation of the various bridge components, all construction is required to be referenced to benchmarks.
- Benchmarks guide all elevation measurements from structure excavation and piledriving to pouring the bridge .
- Benchmarks for bridges are established during the bridge layout and their locationsare usually noted on the layout sheet.
- At least one benchmark on each side of the bridge is required to be checked foraccuracy before construction begins.
- If a benchmark is on a structure that is to be moved, a temporary benchmark is established and protected at a site convenient to the new bridge.
- As soon as a footing or other permanent part of the new structure is poured, the

International Journal of Advance Research in Science and Engineering
Volume No. 11, Issue No. 05, May 2022
www.ijarse.com
IJARSE
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temporary benchmark is transferred to the new structure.

FOUNDATION:

The next step is building the foundation. The foundation rests on the PCC which acts as the rigid impervious bed to the foundation. The formwork and centering is done on the PCC. Then the cover blocks are placed on the PCC. The cover blocks are used for maintaining the level of reinforcement that will be used. The reinforcement at will be placed on the cover blocks and then the concreting is done. The concrete is vibrated by vibrators so that the concrete attains uniformity. The curing is carried out up to requirednumber of days.

GIRDER: Then is girders are casted in the site. The slab is constructed after the girders attain suitable strength

ABUTMENTS: The abutments are constructed at the ends of the bridge where the approach roadway joins the bridge. These abutments act as retaining walls and also pierto the bridge.

Geotechnical Investigation

In order to ascertain the causes of the failures, geotechnical analyses and investigations were carried out. Independent soil investigation was carried out after the failure withthe following

REMEDIAL PLANNING

The remedial treatment of a bridge structure must first be analyzed by the investigation of the problems at hand. Through the case study of the bridge, these problems have been identified and potential solutions are generated. Combining the broad base of knowledge, the system for the remedial works of bridge abutment movement has been created.

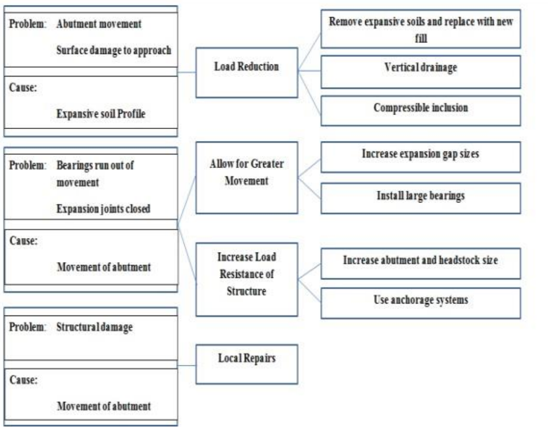

Fig : Problems, causes and remedial options for bridge abutment movement.

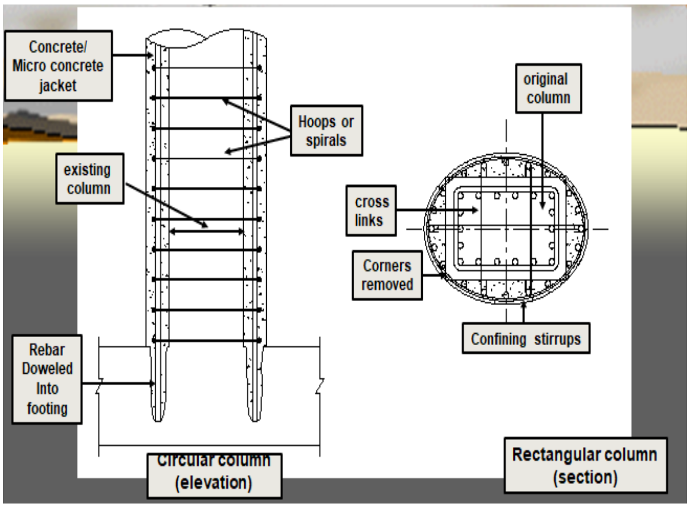

Fig : CONFINEMENT OF COLUMNS BY CONCRETE JACKETING

Decision analysis

Numeric scoring models such as Weighted Constraint Matrix have been developed to allow multiple constraints to be used for concept feasibility studies. These models can combine economic evaluation output with technical and subjective constraint to create a decision making environment that is more holistic (and realistic) in nature.

PIERS

Piers are an integral part of the load path between the superstructure and the foundation. Piers are designed to resist the vertical loads from the superstructure, as well as the horizontal superstructure loads not resisted by the abutments. The magnitude of the superstructure loads applied to each pier shall consider the configuration of the fixed and expansion bearings, the bearing types and the relative stiffness of all of the piers. The analysis to determine the horizontal loads applied at each pier must consider the entire system of piers and abutments and not just the individual pier. The piers shall also resist loads applied directly to them, such as wind loads, ice loads, water pressures and vehicle impact.

Bottom of Footing

Elevation The bottom of footing elevation for piers outside of the floodplain is to be a minimum of 4‟ below finished ground line unless the footings are founded on solid rock. This requirement is intended to place the bottom of the footing below the frost line. A minimum thickness of 2‟-0" shall be used for spread footings and 2‟-6" for pile-supported footings. Spread footings are permitted in streams only if they are founded on rock. Pile cap footings are allowed above the ultimate scour depth elevation if the piling is designed assuming the full scour depth condition. The bottom of footing elevation for pile cap footings in the floodplain is to be a minimum of 6‟ below stable streambed

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ISSN 2319 - 8354

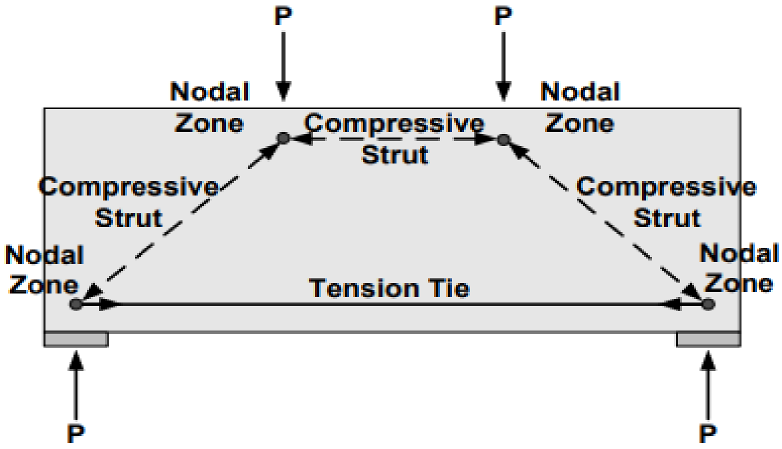
elevation. Stable streambed elevation is the normal low streambed elevation at a given pier location when not under scour conditions. When a pile cap footing in the floodplain is placed on a concrete seal, the bottom of footing is to be a minimum of 4‟ below stable streambed elevation. The bottom of concrete seal elevation is to be a minimum of 8‟ below stable streambed elevation. These requirements are intended to guard against the effects of scour.

Solid Single Shaft / Hammerheads

Strong single shaft docks are utilized for a wide range of intersections and are point by point on Standards for Hammerhead Pier and for Hammerhead Pier – Type 2. The decision between utilizing a multicolumn wharf and a strong single shaft dock depends on financial matters and style. For abnormal state connects, a strong single shaft wharf is commonly the most conservative and appealing dock type accessible. The greatness of this dock type gives a huge parallel burden ability to oppose the to some degree flighty powers from gliding ice, trash and growing ice. They are appropriate for use on real waterways nearby sending channels without extra wharf security. At the point when utilized neighboring railroad tracks, crash dividers are not required. In the event that a cofferdam is required and the upper segment of a solitary shaft dock stretches out over the cofferdam, a discretionary development joint is given 2' over the ordinarywater rise. Since the cofferdam sheet heaping is evacuated by extricating vertically, any overhead block counteracts expulsion and this discretionary development joint enables the contractual worker to expel sheet heaping before continuing with development of the overhanging parts of the wharf. A hammerhead dock will not be utilized when the intersection between the top and the pole would be not exactly the top profundity better than average water. Hammerhead docks are not viewed as stylishly satisfying when the pole presentation above water isn't noteworthy. A possible option in this circumstance would be a divider type strong single shaft dock or a multi-section wharf. On a divider type wharf, both the sides and closures might be inclined whenever wanted, and either around, square or calculated end treatment is worthy. Whenever put in a conduit, a square end type is less attractive than a round or calculated end.

Buoyancy

Buoyancy, a component of water load WA, is specified in LRFD [3.7.2] and is taken as the sum of the vertical components of buoyancy acting on all submerged components. The footings of piers in the floodplain are to be designed for uplift due to buoyancy. Full hydrostatic pressure based on the water depth measured from the bottom of the footing is assumed to act on the bottom of the footing. The upward buoyant forceequals the volume of concrete below the water surface times the unit weight of water. The effect of buoyancy on column design is usually ignored. Use high water elevation when analyzing the pier for overturning. Use low water elevation to determine the maximum vertical load on the footing.



Typical simplistic options For abutment:

Typical simplistic engineering solutions come to mind when the analysis of the Problem of abutment movement is conducted. As the bridge abutment moves, Damage to localized parts of the structure takes place. From an engineering Perspective, the simplest remedial option comes from the local repairs conducted. Although this would do nothing to actually prevent the movement, local repairs can Be used in the short term as as top gap measure in order to buy time while discussion of a permanent remedy is carried out.

Vertical drains

Design of structures on soft compressible soils has created various problems for Engineers. Construction without some sort of ground improvement can lead to negative consequences due to the unpredictable long-term settlement of soil components. Vertical drains are primarily used to increase the rate of settlement of the foundation soil of a structure, but also are used to control high pressure gradients or high pore water pressures. There are various systems for drainage including aggregate filters and synthetic filter materials, as well as pipes and other conduits.

CONCLUSION

This project analyzes the design and behavior of bridge abutments and bridge s when subjected to lateral movement. Theoretical analysis states that the bridge abutment itself should be adequate to withstand the lateral pressures imposed, however, investigation into bridge. Abutment movement has the potential to cause substantial damage to the bridge structure, resulting in high costs of repair and maintenance. The research undertaken has led to the conclusion that abutment movement is a problem of largely unknown quantity and despite investigation, movements may still occur unanticipated. However, these movements can be addressed and rectified through the use of specific actions. The results of the case study highlighted that the problems identified in surrounding soils, road approaches, bridge abutment, and expansion and bearing joints are interconnected. As the soil profile expands, excess loads are placed on the bridge abutment and road approaches. This in turn causes the movement of the abutment into the bridge which creates the structural problems seen in the expansion and bearing joints and also the structural cracking of the concrete in the wing wall of the abutment. These problems, while not immediately critical, will continue to worsen if left untreated as the abutment continues to move, thereby placing increasing Amounts of load on the structure.

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