CROSFALL

Confidential Reporting Of Structural Failures And Lessons Learnt

NEWSLETTER

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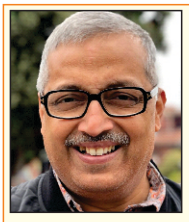
From the Desk of the President

I am extremely happy that editorial board of CROSFALL is coming out with second issue of this unique newsletter. As I mentioned earlier. It is first newsletter of its kind in India which focusses on the structural failures purely from learning point of view. Interesting feature is that identity of the project and the people involved is not revealed and not asked for. The civil & structural engineering fraternity widely appreciated first issue of this newsletter. Gradually people are coming forward to send the reports. Our editorial board members & domain experts are doing fantastic work in evaluating, editing & reviewing the reports before these are published. I am fully confident that this newsletter will serve the civil & structural engineering fraternity in more than one way.

I urge civil & structural engineers to send reports freely without any fear and hesitation. Reports may be for any type of structural failures or structures which have visible gross structural deficiencies having substantial risk of failure. Do send your feedback & suggestions.

– Manoj Mittal

Message from Chief Editor



Welcome to all our CROSFALL readers and subscribers. Since the launch of newsletter CROSFALL in October 2022, we have received number of congratulatory messages which gives an impression that the newsletter is well received by the structural engineering fraternity. However, we are well aware that we are still far from reaching the bulk of the structural engineering community in India and overseas. There is clearly a need to expand our readership, so that more and more of structural engineers and contractors learn from "others" mistake rather than from "their own". So, do please pass on this newsletter to your friends and colleagues who are involved in the profession of civil engineering.

As far as our Editorial Board is concerned since our last newsletter, we are pleased to welcome Dr Vandana Bhatt in our team. In this newsletter, we publish four reports that deal with different, but important topics:

- Report CF-05 – Deals with a reported failure of Reinforced Earth Walls. In the recent past we have seen a number of failures of RE Walls, reflecting problems with design, detailing as well as construction and maintenance. This report is therefore very timely.
- Report CF-06 – Deals with distress reporting on apartments in a multi-storied building. The case is a reflection of the state of affairs in the building industry.
- Report CF-07 – Deals with a classic case of severe corrosion in a steel bridge pier caused due to poor detailing. It shows that a small error in detailing can really create a big problem.
- Report CF-08 – Deals with some real-life examples of failures due to lack of care and negligence in urban Bridges. It is an eye opener to authorities since what is reported here is found in almost all metropolis.

This is the second newsletter of CROSFALL and with the publication of this newsletter, we have published a total of 8 reports covering a wide range of issues, some dealing with particular issues and others of a more general nature. It is observed that majority of the reports that we have been receiving are from bridge sector. We would appeal to all those engineers, working in building sector, tunnelling sector and industrial structure sector to also come forward and contribute in the newsletter. Happy Reading.

– Alok Bhowmick

Contents

REPORT No. CF - 05

Failure Case Studies of Mechanically Stabilised Earth (MSE) Retaining Structures (Highlighting Importance of Connection Design in Performance)

1. Introduction

Mechanically Stabilized Earth (MSE) or Reinforced Soil structures are composite structures consisting of alternating layers of compacted backfill and soil reinforcement elements that are fixed to a facing. The stability of MSE structures is derived from the interaction between the backfill and soil reinforcements, involving friction and tension. The facing is relatively thin and is intended to perform the primary function of preventing erosion of the structural backfill. The significant relative cost saving that can be realized when this system is used compared to traditional RCC retaining structures, combined with ease of construction has resulted in widespread adoption of this technology in India and around the world.

The standards to be followed for the design of reinforced soil walls and slopes find mention in Clause 3100 of the Ministry of Road Transport & Highways (MoRT&H) Specifications for Road & Bridge Works (5th Revision) as well as IRC: SP 102-2014. MoRT&H Clause 3100 allows for the design to be done as per BS 8006:2010 as well as FHWA-NHI-0024. Since BS 8006:2010 does not cover the design checks to be carried out in seismic conditions, the general design approach involves conducting the design checks for the static case as per BS 8006 while the design checks for the seismic case are carried out as per the Mononobe-Okabe pseudo-static approach presented in FHWA-NHI-10-024.

MSE structures designed by adopting this design approach have been found to perform satisfactorily when subjected to static and seismic loading conditions provided that recommended practices are adopted during their construction.

In most MSE systems with fascia panels, the reinforcing elements are connected to the MSE facing by means of a mechanical connection. Depending on the extensibility of the reinforcing element, the type of facing element, and the position of the mechanical connection along the height of the MSE structure, the load on the connection varies from 75% to 100% of the maximum tensile force to be resisted by the corresponding reinforcing layer.

Hence, the mechanical connection is one of the most critical components in an MSE system that has to be designed to accommodate the anticipated connection loads. Recent experiences suggest that incorrectly designed mechanical connections were the fundamental reason for the failure of several MSE structures in India.

This report presents case studies of unsatisfactory performance of some MSE structures with failure resulting primarily due to deficient connection performance.

2. Case Studies

Fig. 1 : Failure of MSE Wall for Case Study

2.1. **Case Study No. 1 :** (Ref. Fig.1)

System : Geogrid with Concrete Panels

Probable reasons for Failure:

- Primary Cause:
- Connection failure, poor connection system and design
- Other added factors
- inadequate detailing
- Drainage criteria not examined
- Poor construction quality

2.2. **Case Study No. 2 :** (Refer Fig. 2)

System Adopted: Polymeric strap + Toggle and loop steel connector

Probable reasons for failure:

- Connection failure
- Corrosion at connection
- Can be either poor quality of galvanization or aggressive backfill
- Collapsed after 15 years- Long term durability issue

Fig. 2 : Connection failure at closing wall and collapse of panel

2.3. **Case Study No. 3: (Refer Fig. 3)**

System : Geogrid + Toggle & Loop Connection

Probable Reasons for failure:

- Connection Failure
- The intact reinforced fill is noteworthy.

Fig. 3 : Failure of MSE Wall due to connection

3. Lessons Learnt :

The primary cause for the failure, generally termed as "Loss of Fascia", in majority of failed MSE walls is poor connection system with other contributory reasons such as poor quality of work, lack of detailing, and inadequate design. Only a few examples are presented here. More focus needs to be given to the connection system and the long-term performance of the connectors.

The connection design of MSE systems is a critical aspect of MSE structure design and is also observed to be the most overlooked in terms of testing. Rigorous connection testing, through reputed institutes like CRRI and IITs, combined with the development of a comprehensive database of connection failures and forensic study findings is very crucial in enhancing understanding of the mechanics at play which can in turn result in scientifically backed stipulations in Indian codes.

The other important topic is the long-term durability of the connection system, which is generally neglected. This is critical with the use of steel components in any connection system. All steel components must be hot dip galvanized if they are exposed to the backfill. The electrochemical properties of the backfill must be in compliance with the specification.

Comments of Expert Panel

The report highlights the failure of connections as primary reason for failure of RS walls combined with the other reasons such as inadequate detailing, Drainage criteria not examined and Poor construction quality. There are various types of Facing Elements, the most common being precast RCC panels, precast concrete blocks, and Gabion facing. The connection details for each of facia type are different. Connection is done by using either nut or bolt, HDPE inserts with bodkin joint, hollow embedded devices, polymeric/steel rods/pipes etc. To ensure their long-term design strength, connections of the panel/block with the reinforcement should be clearly defined and tested as per relevant ASTM standards and the results of these tests should be provided by the supplier. Connection strength and layout once approved, shall not be changed during execution. Several failures have occurred due to improper connections and deviation from the connections proposed in the approved drawings.

All metallic connectors, tie strips and lugs shall be hot dip galvanized as per specifications to protect these against corrosion. Connections have to be designed for full tension in reinforcing elements. The connection failures may also occur due to other reasons such as poor-quality control, inadequate design of facia elements, poor compaction which results in high connection forces. Internal settlement, which is a function of the state of compaction of the reinforced soil and height of the MSE wall, is the major cause of high connection forces. In addition to proper design of RS wall system & connection, the method of construction shall have quality assurance plan and shall meet the applicable MoRTH Specifications and guidelines given by the Vendor to avoid failures of connections and RS walls.

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REPORT No. CF - 06

Distress in three apartments in a multistoried building

1. Introduction

The reporter, who is a structural engineer, was approached by an owner of a flat in a multi-story residential complex to carry out a rapid audit of his flat from safety and stability considerations. He is staying in this flat for many years, but his concerns after so many years became grave after he learnt about serious distress in the nearby tower. The reporter conducted visual inspection on the following:

(a) The exterior periphery of the building

(b) 3 different flats in the building, which were showing signs of distress

(c) Part staircases

The reporter was allowed to photograph the areas of the building inspected by him for his record and making of the report. The building was fairly new and its construction was completed approximately 6 years back.

No structural drawings were available with the flat owner or the RWA of the society. The reporter explained the importance of structural drawings from the safety standpoint of the building occupants and inquired if the owners could obtain the structural drawings of the building for review to which the owner answered that the structural drawings were not available even with the Resident Welfare Association (RWA) and hence it was not possible to obtain these.

The building has one basement, a ground floor, and twelve floors above. Each floor typically has 4 flats and the typical built-up area of a single floor is approximately 6500 Sq. Ft. The residential tower contains two staircases and two lifts.

Before delving into site observations and recommendations, it will be prudent to explain to the readers what types of structural checks exist for buildings. Essentially two types of structural verification are usually performed for the safety auditing of structures:

a) **First:** Checks to ascertain that the structural members i.e. columns, beams, shear walls, floor slabs, etc. still possess their design strength, implying that the concrete and reinforcing steel (assuming an RCC building) still retain their original strength. Any of the structural members losing their strength and load-carrying capacity beyond a limit can cause a local collapse or sometimes a more serious global collapse. To perform this first type of structural check, professionals will undertake visual inspection and may recommend some Non-Destructive Tests

b) The second type of structural check is a more comprehensive structural investigation. In this procedure, the professional structural engineer will determine the capacity of the building to respond/withstand (global structural behavior) the actions and be safety against the most adverse forces that the building may ever face. A structural engineer may suggest Non-Destructive Testing to determine existing concrete strength which he will use for modeling the building study all the structural drawings, build a Finite Element Analysis model in specialized structural software and analyse the building response to vertical loads, wind forces or an expected earthquake as per location and the seismic zone where the building lies as per the applicable national standards.

c) As per the provisions of National Building Code -2016, physical inspection for buildings mentioned in clause 12.2.5.1 needs to be performed every 3 to 5 years and documented for future use and record. However, building owners are not following the same for want of a regulation mechanism. Some building owners/associations are unable to follow the guidelines as mentioned in the National Building Code-2016 of conducting periodical physical inspection as they do not have in their possession copies of the structural drawings. Structural drawings are important for performing the detailed structural safety checks. Non-implementation of this provision of NBC-2016 compromises the safety of the buildings & its occupants as important safety checks may not be performed adequately.

Extract Section 14.4.2 National Building Code 2016 Part-2 Administration, Section-3-Permit and Inspection

14.4.2 All buildings covered under 12.2.5.1 shall be subjected to periodic physical inspection by a team of multi-disciplinary professionals of local Authority. The work by team of professionals may be outsourced by the authority to competent professionals as may be deemed necessary. The term shall ensure the compliance of byelaws, natural lighting, ventilation, etc. besides structural safety, electrical safety and accessibility (for designated public buildings and areas as per 13 of part 3 'Development Control Rules and General Building Requirements' of the Code). After checking, the team shall be required to give the certificate for above aspects. If any shortcoming/deficiencies or violations are noticed during inspection, the authority shall ensure to compliance of these within a specified time frame of six months. If not complied with, the building shall be declared unsafe/unfit. The period of inspection shall unusually be 3 to 5 years but in any case not more than 5 years.

Extract Section 12.3 National Building Code 2016 Part-2 Administration, Section-3-Permit and Inspection

12.3 Preparation and Signing of Plans

The registered architect/engineer/Supervisor/town planner/landscape architect/urban designer/utility service engineer shall prepare and duly sign the plans as per their competence (see Annex A) and shall indicate his/her name, address, qualification and registration number as allotted by the Authority or the body governing such profession. The structural plans and details shall also be prepared and duly signed by the competent professionals like registered engineer/structural engineer (see Annex A). The plans shall also be duly signed by the owner indicating his address. The type and volume of buildings/development work to be undertaken by the registered professionals may generally be as in Annex A.

NOTE : It is applicable for buildings which are 15 m or more in height and for special buildings like educational, assembly, institutional, business, mercantile, industrial, storage and hazardous and mixed occupancies having a covered area of more than 500 sqm.

2. The outcome of Visual Inspection

Based on a visual inspection of the site, the reporter's site observations are as under:

2.1. Basement:

(a) There has evidence of some basement roof beams being supported by fabricated steel supports to have been installed post-construction of the concrete members. As per the owners these steel supports existed in the building since the day, they occupied the building.

(b) There is evidence of a concrete core-cut sample to have been taken from one beam, probably for testing the concrete strength of the beam. The date when this concrete core-cut sample has been extracted could not be ascertained.

2.2. Flat on Ground Floor:

(a) The roof slab of the flat had extensive cracks in multiple rooms. These cracks in the roof slab were serious and needed immediate attention and further urgent action.

(b) The roof slab cracks were photographed for the record.

(c) There was clear evidence of the concrete getting severely degraded in strength, and also corrosion in the reinforcing steel was observed. Corrosion of reinforcing steel had caused swelling, leading to cracks in the floor slab concrete.

(d) The reasons for degradation in the concrete strength can be many. A detailed chemical analysis of existing pieces of concrete taken from the area showing concrete deterioration was required to be performed to establish the cause/s. The reasons can vary from carbonation, exposure to chloride or sulphate attack, and Alkali-Silica/Alkali-Carbonate reaction amongst many others.

(e) The cracks and deterioration noticed in the floor slabs would accelerate with time. The condition will worsen further in due course of time. These cracks in the floor slab were presently visible only from the bottom as the top was covered with vitrified tiles.

(f) The load-carrying capacity of the roof slab of the flat had been jeopardized. It was difficult to say what is the present load-carrying capacity of these floor slabs that are showing serious signs of structural deterioration.

(g) These floor slabs were prone to collapse and therefore as a precautionary measure the occupants should vacate, and the floor slabs should be propped using temporary steel supports until such time all site investigations are completed and permanent structural remedial measures figured out and executed.

(h) The engineer visited only three flats of many that the building has. The same or similar structural vulnerability may be existing in many other areas/flats. The owner was asked to share this report with the Resident Welfare Association and ask them to get all the flats inspected and record the areas that are showing similar signs of structural distress by taking photographs and reporting the same to the concerned authorities.

(i) The following urgent and immediate Non-Destructive Test (within one week of the issue of this report) for the floor slabs showing structural distress is recommended:

(i) Ascertain the concrete strength of the floor slab by extracting a concrete core-cut cylinder from the floor slab in the area showing structural distress (cracks) and testing the same in presence of witnesses representing the residents in an accredited concrete test laboratory.

(ii) One of the two things will happen when testing personnel from the concrete test laboratory come to the site to extract the concrete core from the floor slab. Either they will be successful in extracting a concrete cylinder core using the core cutting machine that they will bring along, in which case the prepared concrete cylinder should be tested using the prescribed Indian Standard procedure by applying a gradually increasing load until the point of failure which would determine that existing concrete compressive strength. The second scenario can be that when the concrete core cut is being attempted the concrete will just crumble and dissipate implying the testing team will not be successful in extracting the concrete cylinder from the floor slab for further laboratory testing. In this, case it should be inferred that the RCC Floor Slab has a negligible residual load carrying capacity unless further tests/checks prove otherwise. The building containing this floor slab should be considered unsafe as the weak floor slab/s can potentially fail/collapse under service loads. Occupants should vacate and the distressed floor/is s propped with steel supports from below. The paperwork along with photographs should be reported to the concerned authorities for further action.

2.3. Flat on Second Floor:

(a) Visible cracks were seen in the roof slab in the balcony area of the flat.

(b) Balcony slab cracks were photographed for the record.

(c) Cracks suggest that the concrete has severely degraded in strength, which has led to corrosion in the reinforcing steel. Corrosion of reinforcing steel has caused it to swell leading to cracks in the floor slab concrete.

(d) The reasons for degradation in the concrete strength can be many. A detailed chemical analysis of existing pieces of concrete taken from the area showing concrete deterioration needs to be performed to establish the cause/s. The reasons can vary from carbonation, exposure to chloride or sulphate attack, and Alkali-Silica/ Alkali-Carbonate reaction amongst many others.

(e) The cracks and deterioration noticed in the floor slabs would accelerate with time. The condition will worsen in due course of time. These cracks in the concrete slab were presently visible only from the bottom as the top is covered with vitrified tiles.

2.4. Flat on Third Floor:

(a) The owners have noticed undulations in vitrified floor tiles.

(b) Presently cracks were not visible on the floor slabs however, it was very much possible that the concrete had deteriorated, and accelerated corrosion of reinforcing steel started. Undulations in the floor tiles are a tell-tale sign.

(c) It is recommended that the owner should get a concrete core-cut sample taken from his floor for Non-Destructive Testing to ascertain the concrete compressive strength as also the concrete condition.

(d) A detailed chemical analysis of existing pieces of concrete will determine the extent of carbonation of concrete if the concrete has been exposed to chloride or sulphate attack or Alkali-Silica/Alkali-Carbonate reaction amongst many others that can accelerate the deterioration in concrete.

3. Recommendations

(a) Urgent and immediate Non-Destructive Test (within one week of issue of this report) for the floor slabs showing structural distress were recommended. The concrete strength of the floor slab should be ascertained by extracting a concrete core-cut cylinder from the floor slab in the area showing structural distress (cracks) and testing the same in presence of witnesses representing the residents in an NABL accredited laboratory.

(b) In the event the concrete just crumbles and dissipates while the concrete core-cut is being attempted on the floor slab, implying that the testing team is not successful in extracting the concrete core-cut cylinder from the floor slab for further laboratory testing. In this case, it should be inferred that the RCC Floor Slab has a negligible residual load carrying capacity unless further tests/checks prove otherwise. The building containing this floor slab should be considered unsafe as the weak floor slab/s can potentially fail/collapse under service loads. Occupants should vacate and the distressed floor/s be propped with steel supports from below. The paperwork along with photographs should be reported to the concerned authorities for further action.

(c) The engineer had visited only three flats of many that exist in the building. The same or similar structural vulnerability may be existing in many other areas/flats. Resident Welfare Association should get all the flats inspected and record the areas that are showing similar signs of structural distress by taking photographs and reporting the same to the concerned authorities.

(d) The Resident Welfare Association should order a comprehensive structural investigation of the building as explained in this report. For a comprehensive structural audit to take place the Resident Welfare Association will need to obtain all the structural drawings from the concerned authorities.

Comments of Expert Panel

It is important for the occupants of any buildings and/or their representative apartment associations / RWAs to get periodic structural auditing done as per the provisions of NBC-2016 and other codes. There is also urgent need for the regulatory authorities to ensure this. Owners must make sure that they have copy of As-Built structural drawings and other documents pertaining to their apartment / building structure e.g. completion drawings, design Basis report, Soil investigation report, names of all professionals including the contractor/builder involved in the construction of the said apartment/building. Any distress noticed must be brought to the notice of concerned authorities. Visual inspection/Structural assessment / Detailed Structural Audit of the buildings must be carried out by a competent engineer as per the procedures laid down in BIS standards, following sound engineering practices. Structural repair, strengthening or retrofitting suggested by the structural engineer should be taken seriously and got done without any delay. Guidance, strict supervision and quality assurance by competent qualified engineers is a must during the whole process.

Fig. 1 : Some basement beams are supported by fabricated steel columns.

Fig. 4 : Indoor view of ground floor flat

Fig. 2 : Side view of the steel column supporting the basement beam.

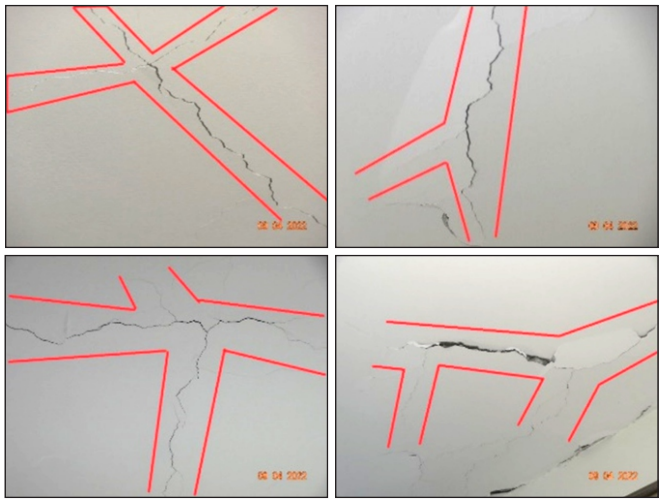

Fig. 5 : visible cracks on the roof slab

Fig. 3 : Concrete Core cut sample has been taken from basement beam.

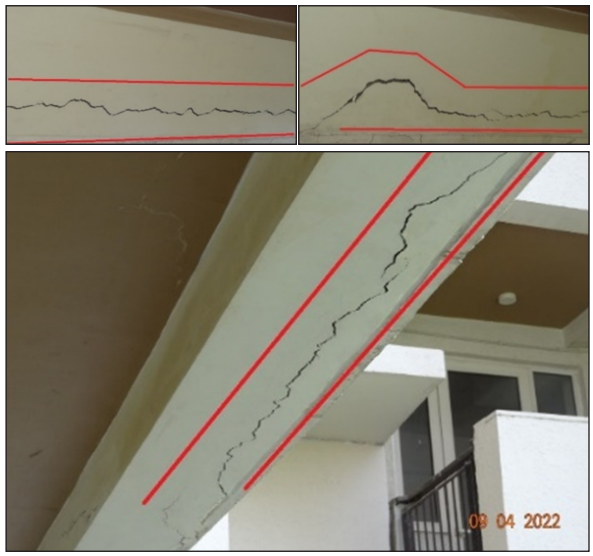

Fig. 6 : Indoor view of ground floor flat

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REPORT No. CF - 07

Poor Detailing causes Severe Corrosion in Steel Piers of a Flyover

The reporter, in this case, is a structural engineer who has reported severe corrosion in the Steel Pier Base Plate of an existing flyover in one of the busiest metro cities, located in a very busy road crossing.

1. The Existing Structure:

The flyover comprises a 45m long girder which is a steel trapezoidal box girder and the rest 25m spans are made of 5 nos. of Steel Plate girders. The entire deck is of RCC composite construction. The foundation is of bored cast-in-situ RCC Piles with RCC Pile Caps. Piers and Pier Caps are made out of steel structures. All piers are single columns with cantilever arms on both sides. Bearing used for the 25m span girders are Neoprene type and POT PTFE type for the Box Girder. The maximum height clearance at the obligatory span is a little above 5.5m from the road surface. Construction of this flyover took little more than three years and the same was commissioned sometime in the year 2002. Fig.1 shows a view of the Flyover from surface road level.

Fig. 1 : View of the distressed Flyover from surface road level

2. The Problem:

It is a case of a serious level of corrosion in the gridded Base Plate of steel box type pier. The probable cause of corrosion is the poor detailing of the steel pier. There was no provision kept for drainage of any seepage water from inside the box-type steel piers. Fig. 2 below shows some photographs from inside the pier.

Fig. 2 : View of the corroded steel pier box from inside

3. The Diagnosis:

Faulty detailing in the gridded portion in the base plate is the cause that leads to retention of the water that percolated inside the pier box section through gaps at the end of the different splice joints. It is obvious that while fabricating pier base using steel plates to form grids, a number of separated compartments will form. Unless some drainage slots/openings are left at the bottom corner of each plate and also in the main plates (4 sides), percolated water will automatically get accumulated inside the pier box.

4. Lessons Learnt and Proposed Remedial Measures:

Closed box-type steel piers in no way can be made fully watertight. Every possibility is there for the rainwater to get inside the pier box through the gaps at the end of the splice cover plates at splicing joints. As a result, any water that gets inside the pier box will reach the base of the piers and finally, the compartments created in between the main and cross stiffener plates will get filled up. To avoid such undesired happenings in the future, appropriate provisions have to be there in the base plate fabrication drawings, during construction, for early draining out of such accumulated water.

Remedial measures can be thought of as:

a. The main stiffener plates and cross stiffener plates must have a small opening at their bottom at all the joining locations. This has to be suitably shown in detail in the fabrication drawings. Such openings may be of size 10mm x 10mm cut at the bottom ends. All these openings will allow the accumulated water to flow out from one compartment to the other and finally reach any of the four edges. The main four plates (vertical) of the Pier box structure also have 10mm diameter holes at the base plate level to allow the accumulated water to finally drain out of the pier base. Such holes (on all the four sides) must have stainless steel drain pipes, protruding out of the pier vertical surfaces to ensure non-clogging of such openings due to concrete embedding at the pier bases.

b. Non-Shrink Grout Concrete to be filled up after installation of the base plate stiffeners (grillages) to a height about 75mm above the stiffener plate top level. After filling of Non-shrink grout concrete, like done earlier, stainless steel drain pipes are to be installed on all the four sides of the pier plates after making holes of diameter 10 mm. Such holes are to be at the level on the top surface of the finished concrete.

c. Anti-corrosive paint inside the piers and closed box section should be made mandatory. Manual cleaning using Steel Brushes & Steel Scrapers and then followed by the application of 2 coats of Zinc-Rich Epoxy of 20 micron (total), which is as per Table D-2 of Annex-D of IRC:24 - 2010 should be followed in such cases.

d. Access to inside of pier should be provided for regular inspection and maintenance.

e. Hollow steel piers where inside accessibility is a problem, should be avoided.

Comments of Expert Panel

Hollow steel box type piers can be prone to corrosion due to water accumulation inside the base if proper attention to water drainage provisions and holes are not made at the time of design and in the drawings itself. Water finds its way into the steel box pier through splice plates between segments of the box piers.

Structural designers must pay attention to this important detail to avoid corrosion due to water accumulation and also specify durability enhancing measures in their drawings.

The IRC-24 Code shall include such specific and necessary clauses in this regard to ensure adoption of drainage provisions and durability enhancing measures in hollow box piers held at the time of design and during fabrication.

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REPORT No. CF - 08

Failures due to Lack of Care and Negligence in Bridges

1. Distress/Failure due to Unsafe Environment:

In this case, the reporter has reported a number of cases of bridge distress/failure caused due to the creation of unsafe conditions around the bridge and due to poor maintenance of the bridges. The damages to a Bridges are usually linked to:

a. Error in design/ deficiency in the implementation of design principles during detailing

b. Use of materials not conforming with specifications during construction

c. Lack of stability during construction/ improper construction methodology

d. Inadequate Inspection and maintenance practices

There is, however, another avoidable common reason i.e., the unsafe conditions created around the structures, some of which are man-made and often deliberate.

One will find from the attached pictures:

a. instances of damage caused due to the growth of greens on the structure, (Fig. 1 to 4)

b. informal settlers using the underside of the bridge as their habitat unimpeded, (Fig. 5 & 6)

c. use of the underside of the structure for residential, commercial and industrial purposes, officially sanctioned by the authorities, (Fig. 7 to 9)

d. instances where the design and detailing of structure does not permit essential maintenance work to be done because of a lack of access to such location. (Fig. 10 to 14)

A. **Instances of damage caused due to the growth of greens on the structure-plants have caused corrosion and spalling of concrete cover.**

Fig. 1

Fig. 2

Fig. 3

Fig. 4

B. Informal settler used the underside of the bridge without any interference - leading to severe damages

Fig. 5

Fig. 6

C. Use the underside of the structure for residential, commercial and industrial purposes, with official sanction - leading to permanent damage

Fig. 7

Fig. 8

Fig. 9

D. Instances where the design and detailing of structure do not permit essential maintenance work to be done because of a lack of access to such location

Case 1 : Bridge across electrified railway tracks does not permit any inspection & maintenance work to be done- corrosion started due to lack of concrete flow due to congestion of Rods/PSC wires

Fig. 10

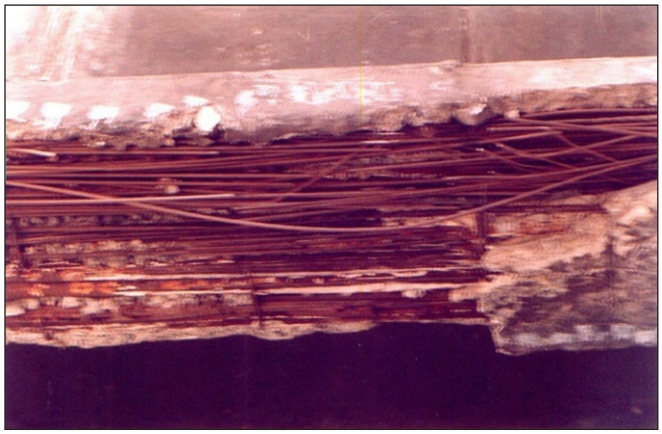

Fig. 11

Fig. 12

Case 2 : No access to underside of bridge left damages unnoticed leading to catastrophic failure of poorly designed gussets.

Fig. 13

Fig. 14

2. Lessons Learnt:

It is essential that the statutory responsibility for avoidance of such damage is assigned to the authorities in-charge and their designers. The designers should be made responsible for the preparation of the maintenance manual with a specific schedule for undertaking inspection and recommended corrective procedures/ rehabilitation work. Access to all parts of the bridge should be ensured during the design stage and provisions for the same must be kept. Owner agencies should carry out regular inspections and maintenance.

Comments of Expert Panel

Inspection and maintenance of bridges is a neglected area in our country. Apart from regular inspection of various components of a bridge like bearings, expansion joints, superstructure, substructure, railings and wearing coat etc., it is important to look for concrete and steel deterioration, spalling of concrete, loss of cover leading to exposure of steel reinforcement and cables leading to their corrosion which may be caused by other reasons reported in this article. The reporter has reported instances of "unsafe environment around the structure" which are normally overlooked. The growth of vegetation in superstructure as seen in the Figs. shall cause non-functioning of expansion joints, moisture ingress, cracks, delamination and spalling in the concrete thereby exposing the reinforcement and causing degradation of concrete. When underside of bridge is used for residential and commercial purposes, the smoke emanating from cooking or similar activities will be harmful to the concrete and affect the durability of the structure. Heavy vehicles parked below may cause collision with the piers. Lack of access to the underside of superstructure, pier cap, bearings etc. will block the inspection and maintenance activities because of which damage caused may go unnoticed for years and lead to unexpected failure of the structure. Regular inspection, maintenance, proper access to all parts of the bridge and enforcement of laws to provide safe environment around the structure should be ensured by authorities to prevent the damage to the structure and ensure its durability and longevity.

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Comments received on 1st issue of CROSFALL Newsletter

Thank you for your email and for sending the CROSFALL Newsletter. Although the failures occurring in many other countries are analyzed and the final report presented for the engineers to learn from them, In India they are reported in the Newspapers when they occur. Even though some committees are formed, the final report is not made public. In these conditions, your efforts are to be appreciated. Congratulations. Hope you will get more reporting of such failures, which will be useful to the young engineers not to repeat them in their work.

- Dr. N. Subramanian
FNAE, FIE, F.AS E
Consulting Engineer, Gaithersburg, MD-20878

Fantastic initiative. Kindly let me include in the circulation list. In turn, I will attempt to report a few failures that I have witnessed and studied in Buildings Segment. If there is a subscription let me know.

- Mr Girish Dravid
Director, Sterling Engineering Consultancy Services

This is an excellent initiative Mr. Alok. Hearty compliments to you & team. It's very essential for the fraternity.

– Mr. Ramachandra V.
Head – Tech Services, UltraTech Cements

Congratulations to CROSFALL! Very interesting and helpful.

I just came back from a 6 months sabbatical named "building in Africa". We drove by car from Cape Town to Cairo. Now I need to get started here again but I will keep my eyes open regarding your request.

- Dr. Mike Schlaich
Partner at Schlaich Bergermann Partner

This is a commendable initiative, Er. Alok Bhowmick Ji. Hearty congratulations on this maiden issue.

- Er. H.R. Girish,
Chairman, ICI-Bengaluru Centre

Many thanks for sharing the inaugural issue of your CROSFALL newsletter.

I look forward to sharing the information with my CROSS colleagues here in the UK and through them, to CROSS-USA.

Congratulations on bringing this initiative to fruition.

- Mr. Martin Powell
Chief Executive, The Institution of Structural Engineers

Great initiative, Alok. I would like to post it on my FCE Facebook page. I've posted it on the FCE and the Civil Engineering Discussions WA pages too.

-Mr. B. S. C. Rao
Former Executive Director, BMRCL

This is a fantastic effort. Kudos to you and your team. All the best.

-Prof. Prem Krishna
Retd. Professor, IIT, Roorkee

Congratulations and thanks for 1st inaugural issue of CROSFALL.

- Er. Rajesh Gangwar
Consulting Engineers

This is very good. Congratulations for coming out with such a publication.

- Mr Deepak Singh
Lead DRM Specialist at World Bank

Many practical aspects and details are being explained by experts with confidence, these aspects are not available in a single book and most of the civil Engineering professional may not have heard of all the issues discussed in this program. Wonderful, keep it up. May God Bless you and you keep on serving the fraternity. Regards. Jai Hind.

-Mr. I. J. Ghai
Consulting Engineers Associates (C.E.A.)

Many thanks for sharing this Newsletter. This is an excellent imitative! Well done.

- Ms Henrike Brecht
Senior DRM Specialist, World Bank

About the CROSFALL Newsletter

CROSFALL is a unique newsletter created by Indian Association of Structural Engineers (IAStructE). Its purpose is to share lessons learnt from structural failures, near-misses and safety concerns. CROSFALL has a confidential reporting system, which allow safety issues to be reported by professionals, without exposing their identity and without creating concerns in areas like co-worker relations, client loyalty, or insurance. Any identifiable details, such as a project, product, individual or organization, will remain completely confidential to CROSFALL editorial team. Reporters' personal information will be collected to only verify the contents of the report, and to communicate with the reporter if necessary, but this will also remain strictly confidential.

The newsletter will report only safety related issues with the objective to learn lessons from such failures and to help prevent future structural failures, by providing insight into root causes of such failures and spurring the development of safety improvement measures.

CROSFALL team will depend on professionals to submit reports, whenever they can share their concerns about what they see around or what they experience on any real-life projects. Anyone involved in the civil engineering industry is welcome to submit a report. The more reports submitted, the better CROSFALL can identify and quantify safety issues across the industry. This will help the entire industry to learn lesson from CROSFALL publications.

What can be reported?

- Structural failures,
- Poor Design and Detailing, Lack of Seismic Safety in planning
- Safety concerns about high risk erection schemes at Site
- Safety concerns on Temporary Works
- Near misses or observations relating to procedures followed at site, which may lead to failures or collapses.

To submit the report :

Visit : www.iastructe.co.in/crosfall.php

E-mail : crosfall.iastructe@gmail.com