# പതിനാലാം കേരള നിയമസഭ
## പതിനാറാം സമ്മേളനം

**നക്ഷത്ര ചിഹ്നമിടാത്ത ചോദ്യം നം.1231** **31.10.2019 ൽ മറുപടിക്ക്**

**പാലാരിവട്ടം പാലം**

**ചോദ്യം**
**ശ്രീ.കെ.വി.വിജയദാസ്**

**മറുപടി**
**ശ്രീ.ജി.സുധാകരൻ**
**(പൊതുമരാമത്തും രജിസ്ട്രേഷനും വകുപ്പ് മന്ത്രി)**

(എ) പാലാരിവട്ടം പാലത്തിന്റെ നിർമ്മാണ ക്രമക്കേടുമായി ബന്ധപ്പെട്ട് മദ്രാസ് ഐ.ഐ.റ്റി.യുടെ കണ്ടെത്തലുകൾ എന്തെല്ലാമാണെന്ന് വ്യക്തമാക്കാമോ;

(എ) പാലാരിവട്ടം പാലത്തിന്റെ ബലക്ഷയം സംബന്ധിച്ച് മദ്രാസ് ഐ.ഐ.റ്റി.യിലെ വിദഗ്ധർ പരിശോധന നടത്തിയിരുന്നു. ഐ.ഐ.റ്റി യുടെ ഫൈനൽ റിപ്പോർട്ട് അനുബന്ധം 1 ആയി ചേർക്കുന്നു.

(ബി) പ്രസ്തുത നിർമ്മാണവുമായി ബന്ധപ്പെട്ട് ശ്രീ. ഇ.ശ്രീധരന്റെ കണ്ടെത്തലുകളുടെ വിശദവിവരം നൽകുമോ;

(ബി) പാലാരിവട്ടം പാലത്തിന്റെ ബലക്ഷയം സംബന്ധിച്ച് ചെന്നൈ ഐ.ഐ.റ്റി യുടെ ഫൈനൽ റിപ്പോർട്ടിന്മേൽ ഡി.എം.ആർ.സി പ്രിൻസിപ്പൽ അഡ്വൈസർ ഡോ.ഇ.ശ്രീധരൻ സമർപ്പിച്ച റിപ്പോർട്ടിന്റെ പകർപ്പ് അനുബന്ധം II ആയി ചേർക്കുന്നു.

(സി) പ്രസ്തുത റിപ്പോർട്ടുകളിൽ ഏതാണ് സർക്കാർ സ്വീകരിച്ചതെന്ന് വെളിപ്പെടുത്താമോ ; എങ്കിൽ വിശദാംശം നൽകാമോ;

(ഡി) ടി പാലം പുതുക്കിപണിയുന്ന കാര്യത്തിൽ കൈക്കൊണ്ടിട്ടുള്ള തീരുമാനം എന്താണെന്ന് അറിയിക്കാമോ?

(സി) & (ഡി) പാലാരിവട്ടം പാലത്തിന്റെ ബലക്ഷയം സംബന്ധിച്ച് ചെന്നൈ ഐ.ഐ.റ്റിയുടെ റിപ്പോർട്ട് ,ഡി.എം.ആർ.സി പ്രിൻസിപ്പൽ അഡ്വൈസർ ഡോ.ഇ.ശ്രീധരൻ സമർപ്പിച്ച റിപ്പോർട്ട് എന്നിവ പരിശോധിച്ച് നിർദ്ദേശങ്ങൾ സമർപ്പിക്കുന്നതിനായി ചീഫ് എഞ്ചിനീയർമാർ ഉൾപ്പെട്ട ഒരു വിദഗ്ധ സമിതിയെ സർക്കാർ നിയോഗിക്കുകയും ആ വിദഗ്ധസമിതിയുടെ റിപ്പോർട്ടിന്റെ അടിസ്ഥാനത്തിൽ ഡോ.ഇ.ശ്രീധരൻ സമർപ്പിച്ച നിർദ്ദേശം അംഗീകരിക്കുകയും സഉ(കൈ) നം.52/2019/പൊമവ തീയതി 25.10.2019 പ്രകാരം പാലത്തിന്റെ പുനരുദ്ധാരണ പ്രവൃത്തി ഡി.എം.ആർ.സി യെ ഏൽപ്പിക്കാൻ ഉത്തരവാകുകയും ചെയ്തിട്ടുണ്ട്.

**സെക്ഷൻ ഓഫീസർ**

3842687/2019/(D) PWD

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Dr. P. Alagusundaramoorthy
Professor

To 12-09-2019

**The Managing Director,**
Roads and Bridges Development Corporation of Kerala Ltd.,
2nd Floor, Preethi Building,
M.V. Road, Palarivattom,
Kochi - 682 024,
Kerala State.

Sir,

Sub: Design and Construction of Palarivattom Flyover in in NH66 (Old NH 47) By pass - Rectification Works - Reg.

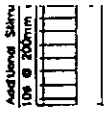
Ref: Repair and Rehabilitation Procedures for Girders and Pier Caps - IIT Madras Report III dt. 05-09-2019.

Please refer the above reference. The following procedures using Concrete Jacketing shall be used to repair and flexural and shear strengthening of precast RC Girders (instead of carbon fiber wrapping for shear strengthening of Girders) and Pier Caps in the flyover at NH-66, Palarivattom, Kochi:

(i) **Flexural Strengthening of Precast RC girders by Concrete Jacketing (Report III, Page 10, Sec. 5.0).**

(ii) **Shear Strengthening of Precast RC girders by Concrete Jacketing**

Additional stirrups using 10mm dia. TMT steel rebars at a spacing of 200mm c/c shall be added by concrete jacketing to increase shear capacity of girders. The cover concrete on girders upto a length of 5500 mm from the diaphragm beams (both ends) have to be removed/roughened and steel rods exposed. The prepared surfaces shall be cleaned from dust and debris. The position of additional stirrups (Fig. 11) has to be marked on the girders. Additional stirrups shall be anchored into the deck slab as shown in Fig. 12 using anchoring grout. 10mm dia. 150 mm depth TMT steel rebars (shear keys) at a spacing of one meter interval in a staggered manner shall be fixed (Fig. 12). Water tight shuttering shall be provided in two stages. Shrinkage compensated free flowing micro-concrete which attains a compressive strength of 35 N/mm$^2$ in three days shall be poured in to the corresponding shuttering. Deck slabs need not be drilled for pouring micro-concrete. Side shuttering shall be removed after three days. Bottom shuttering shall be removed after 7 days. Proper curing to be done as per the manufacturers catalogue for micro-concrete. The process of shear strengthening shall be done in parallel with the flexural strengthening (Report III, Page 10, Sec. 5.0) of girders.



(iii) **Cross Stiffening of Precast RC Girders (Report III, Page 8, Sec. 4.0)**

(iv) **Repair and Strengthening of Pier Caps (Report III, Page 11, Sec. 6.0)**

The estimated cost to repair and strengthen the flyover by concrete jacketing is given in Table 3.0. The flexural strengthening and shear strengthening of precast RC Girders and Pier caps can be done by Concrete Jacketing.

**Table 3. Repair and Strengthen the Flyover using Concrete Jacketing**

| Sl. No. | Repair and Strengthening Item and Technique | Cost (Rs./Crores) |
|---|---|---|
| 1. | Flexural strengthening of precast RC girders by concrete jacketing | 3.17 |
| 2. | Shear strengthening of precast RC girders by concrete jacketing | 1.30 |
| 3. | Cross stiffening of precast RC girders using standard steel sections | 1.20 |
| 4. | Repairing of cracks in precast RC girders by resin injection | 0.28 |
| 5. | Repairing of cracks in RC retaining walls at abutments | 0.10 |
| 6 | Repair and strengthening of pier caps including the cracks | 1.08 |
| | **Total** | **7.13** |

Total duration: 9 months.

(v) **Overall View of Carbon Fiber Fabric Composites**

The applicators guarantee period for carbon fiber fabric composites is ten years. Carbon fiber fabric composites will never corrode. They cannot be affected by any chemical environment. Carbon fiber fabric composites will last for a longer period than the guarantee period. If carbon fiber fabric composite wrapping is damaged accidentally, it can be repaired easily. Since carbon fiber fabric composites on an average four times stronger than steel and four times lighter than steel, they are selected for shear strengthening of girders in order to reduce the repair time and additional dead load on Pier Caps. Carbon fiber wrapping is one of the standard procedures for shear strengthening of RC Girders. If not preferred, shear strengthening of RC Girders shall be done by the conventional concrete jacketing as explained above in Sec. (ii).

IIT Madras will issue the execution drawings as per the requirement. Scaffolding, water supply and power supply have to be provided as per the site conditions by RBDCK/RDS. After repair and strengthening a span and two pier caps, a load test to be conducted and the measured deflection can be checked with the allowable limit to ensure the safety of the bridge. Strict quality control to be ensured during the repair and strengthening of Flyover. All safety procedures for manpower and machines to be ensured by the Applicators.

Thanking you

Yours faithfully

P. Alagusundaramoorthy

(Dr. P. Alagusundaramoorthy)

12.09.2019

Dr. P. ALAGUSUNDARAMOORTHY
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# CONDITION ASSESSMENT AND REPAIR AND REHABILITATION OF FLYOVER AT PALARIVATTOM IN NH66

Report III

## Repair and Rehabilitation Procedures for Girders and Pier Caps

RB/18-19/CIE/014/ROAS/PALA

Client

ROADS AND BRIDGES DEVELOPMENT CORPORATION KERALA LIMITED

Kerala

Consultant

Prof. P. Alagusundaramoorthy

STRUCTURAL ENGINEERING LABORATORY
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# CERTIFICATE

The details of repair and rehabilitation procedures for the precast RC girders and pier caps in the flyover in NH-66 at Palarivattom, Kochi, and the cost estimation are given in this report.

P. Alagusundaramoorthy

(Dr. P. Alagusundaramoorthy)

03.09.2019

IIT Madras ★ Structural Engg. Lab. Dept. of Civil Engg. ★ Chennai-36

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# CONDITION ASSESSMENT AND REPAIR AND REHABILITATION OF FLYOVER AT PALARIVATTOM IN NH66

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# CONDITION ASSESSMENT AND REPAIR AND REHABILITATION OF FLYOVER AT PALARIVATTOM IN NH66

## 1.0 INTRODUCTION

The General Manager (i/c), Roads and Bridges Development Corporation of Kerala Limited (RBDCK) asked IIT Madras to inspect the distressed flyover in NH 66 at Palarivattom, Kochi and to assess the existing condition of the flyover, scrutinize the structural design to identify deficiency in design and construction if any, recommend suitable rectification works and identify the lapses if any on the part of Contractor and Consultant (RBDCK/T 123/Vol. 4/883, ltr. dt. 04.06.2018). Dr. P. Alagusundaramoorthy, Professor, and Mr. R. Rajasekaran, Senior Project Officer, Structural Engineering Laboratory, Civil Engineering Department, IIT Madras visited Kochi on 01-08-2018 and inspected the flyover at Palarivattom in NH 66. Mr. Alex T Joseph, GM (i/c), Ms. Lissey, AGM, Ms. Maya M.J, Senior Manager, Mr. Shalimar M.S, Senior Consultant, Mr. Pramod G, JGM and Mr. Antony Shyam, Senior Planning Engineer, RDS were present during the inspection of the flyover. Flexural, shear and flexural shear cracks are noticed on the precast RC girders in almost all spans. Structural cracks are observed on certain pier caps. One of the pot bearing at Pier No. P18 has failed. Certain neoprene bearing pads are also distressed. The bitumen coat on the flyover debonded. Settlement of embankment on the expansion joint at Pier No. P1 is noticed. Vertical cracks are noticed on certain portions of the RC wall of the embankment. From the preliminary inspection, it is noted that the flyover is in distress.

IIT Madras suggested to RBDCK to conduct NDTs and PDTs and check the structural design of the superstructure and foundation with the existing strength of concrete. IIT Madras asked RBDCK to repair and rehabilitate the flyover as early as possible. IIT Madras submitted the proposal to scrutinize the structural design to identify any deficiency in the design of flyover, conduct the non-destructive tests (NDTs) such as Ultrasonic Pulse Velocity (UPV) and Schmidt Rebound Hammer Number tests on selected thirteen RC girders and four piers, extract concrete cores from thirteen RC girders, four piers and RC walls of embankment, suggest suitable repair and rehabilitation/strengthening procedures along with materials and specifications, prepare BOQ for repair and rehabilitation of the flyover and as per the requirement check the quality of repair materials and periodical inspection of the repair and rehabilitation works. The proposal sent by IIT Madras was approved by RBDCK and IIT Madras commenced the subject scope of work. The details of testing and conclusions

# LIST OF FIGURES

### 3.4 Near Surface Mounting Technique

Flexural strengthening of RC girders by NSM technique using CFRP composite rebars, shear strengthening using carbon fibre fabric composites and arresting the cracks by injecting low viscous epoxy vinyl ester resin.

### 3.5 Concrete Jacketing

Flexural strengthening by adding additional steel reinforcements at the bottom of precast RC girders using shear keys and microconcrete, shear strengthening using carbon fibre fabric composites and arresting the cracks by injecting low viscous epoxy vinyl ester resin.

## 4.0 REPAIRING AND STRENGTHENING OF PRECAST RC GIRDERS USING NSM TECHNIQUE

### 4.1 Repairing of Cracks

6 mm dia and 125 mm deep holes have to be drilled at a spacing of 350 mm c/c (4 Nos/m crack length) along the crack length and 6 mm dia. 75 mm length nozzles to be fixed using epoxy putty. Low viscous epoxy vinyl ester resin has to be pumped under pressure till refusal. The nozzles have to be cut after grouting and finished with fast setting polymer mortar.

### 4.2 Flexural Strengthening of RC Girders Using CFRP Composite Rebars

Four numbers of 32 mm dia. CFRP composite rebars having a tensile strength of 1800 N/mm$^2$ and tensile modulus 2.1 x $10^5$ are to be added to the bottom of the girders. Grooves of size 48 mm x 48 mm at a spacing of 118mm c/c have to be cut at the bottom cover concrete. The grooves have to be cleaned from dust. A layer of adhesive epoxy resin upto 3 mm thick have to be applied on the top of the groove. CFRP composite rebars have to be kept in position below the layer of resin and the entire length of groove be filled with adhesive epoxy resin. Excess resin has to be wiped out and the bottom surface to be levelled and trowel in line with the bottom cover concrete. Proper packing using wooden planks and wooden jacks shall be given upto a minimum of 3 hours/till the curing of the resin (as per manufacturers data) and the packing be removed for air curing of resin. The schematic diagram of layout of CFRP composite rebars in a girder is shown in Fig. 1. The size and dimension of grooves and position of CFRP composite rebars in the cross section of a girder are shown in Fig. 2.

from testing are given in Report 1. The analysis of the flyover and conclusions arrived from the analyses are given in Report 2. The repair and retrofitting (strengthening) of precast RC girders, cross stiffening of precast RC girders and repair and strengthening of Pier caps are given in this report. The cracks on RC walls at the abutments have to be repaired. The condition of pedestals and POT CUM PTFE bearings in the obligatory PSC girder (Center) span P9 P10 have to be checked and the pedestals to be repaired/recast and the bearings be replaced if needed.

## 3.0 REPAIR AND STRENGTHENING OF FLYOVER

The flyover consists of seventeen standard spans with precast RC girders and two obligatory spans with PSC girders supported on two abutments AP1 and AP2 and eighteen piers (P1 to P18). Each standard span consists of six precast RC girders connected to two end diaphragm beams supported by bearing pads on the pier caps. Based on the non-destructive and partially destructive tests and analyses, IIT Madras suggested to repair and strengthen the precast RC girders in seventeen standard spans and pier caps in eighteen piers P1 to P18. All precast RC girders to be strengthened for (i) flexure to enhance the effective moment of inertia and thereby reduce the deflection and (ii) shear to account for the increase in shear capacity due to flexural strengthening. The flexural, shear and flexural shear cracks on the girders to be arrested. The flexural and shear cracks in the Pier caps to be arrested. All Pier caps to be repaired and strengthened for both flexure and shear deficiency.

IIT Madras explored the possibility of repairing and strengthening the precast RC girders using (i) Concrete jacketing, (ii) Steel jacketing, (iii) External flexural strengthening using CFRP composite pultruded sheets, (iv) Strengthening of girders by near surface mounting (NSM) technique using CFRP composite pultruded sheets, (v) Strengthening of girders by NSM technique using pultruded CFRP composite rebars and (vi) Shear strengthening using carbon fibre fabric composites. The possibility of repairing and strengthening the Piers using (i) carbon fibre fabric composites and (ii) and Concrete jacketing are also explored.

Considering the durability, cost and time to repair and strengthen the precast RC girders the following two schemes such as (i) Near Surface Mounting Technique and (ii) Concrete jacketing are preferred:

**4.4 Shear Strengthening of RC girders**

Carbon fibre fabric of 230 gsm having a width of 500 mm shall be used for shear strengthening of girders to have additional shear capacity due to increase in flexural strengthening of girders under NSM technique. Ten pieces of carbon fibre fabric upto a size of 4500 mm x 500 mm ($\ell$ x $b$) have to be cut and kept ready. The concrete substrate on the girder upto a length of 5500 mm from the diaphragm beams (both ends) have to be roughened by sand blasting/wire brush and cleaned from dust and debris. The position of 'U' wraps has to be marked on the girders. A layer of epoxy primer to be applied on the prepared (roughened) concrete substrate. After the tack free time of primer, a layer of catalysed saturating epoxy resin to be applied on the primer coat and the fabric be bonded on the catalysed resin. Another layer of catalysed epoxy resin to be applied on the fabric for proper wetting and bonding. Serrated rollers be used to remove the air bubbles and proper bonding of carbon fibre fabric. All 'U' wraps shall be bonded (anchored) on the deck slab upto 100 mm on both ends. The schematic diagram of 'U' wraps in a girder is shown in Figs. 3 and 4.

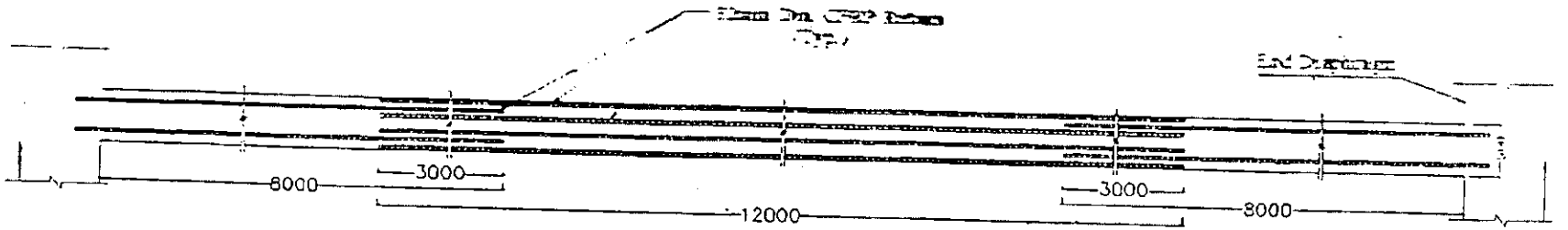



FIG. 1 LAYOUT OF CFRP COMPOSITE REBARS FOR FLEXURAL STRENGTHENING OF GIRDERS USING NSM TECHNIQUE

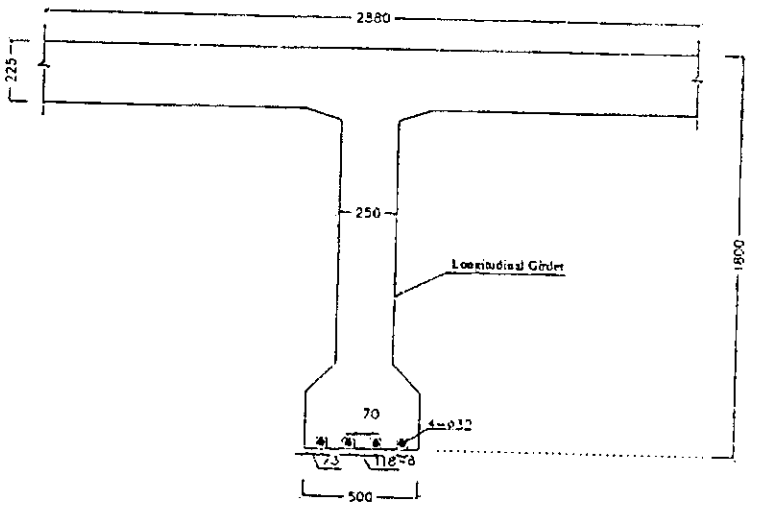



Fig.-2

FIG.-2 POSITION OF GROOVES AND CFRP COMPOSITE REBARS IN THE CROSS SECTION OF A GIRDER

## 4.0 CROSS STIFFENING OF RC PRECAST GIRDERS

Apart from the two end diaphragm beams, all precast RC longitudinal girders in the seventeen standard spans have to be cross stiffened at a distance of 5.063 m ($\ell/4$), 10.125 m ($\ell/2$) and 15.188 m ($3\ell/4$) from any one of the end diaphragm beams for lateral stability and control of vibration. The cross girders shall be integrated to the deck slab using shear keys. Steel girders of ISWB 600 @ 145.1 kg/m shall be used for cross stiffening. The length of each cross girder in between the longitudinal precast RC girders is 2630 mm. Steel plates of size 700 mm x 400 mm x 20 mm thick shall be used for connecting the steel girders with RC girders. The end plates and two ends of the cross girders shall be fabricated in line with the longitudinal girders suitable for connections. 8 nos. of 20 mm dia. bolts shall be used for connecting the steel cross girders to the longitudinal precast RC girders. The schematic diagram of layout of steel cross girders and the connections are shown in Figs. 5, 6 and 7.

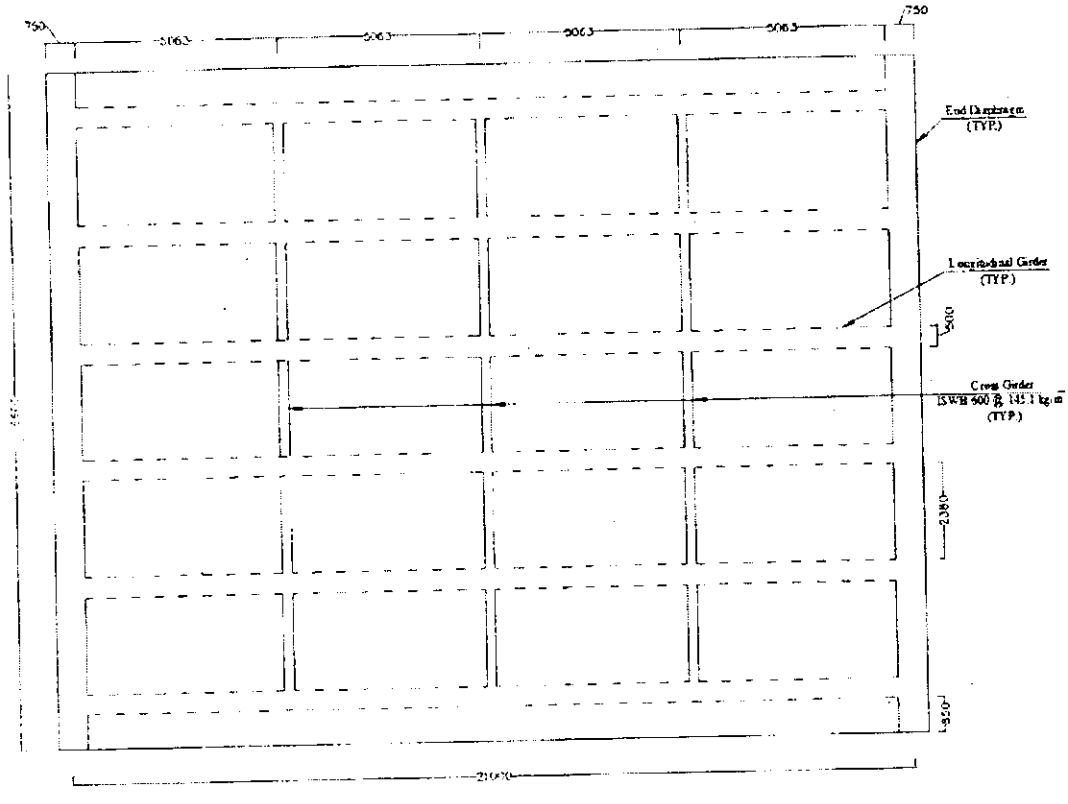



FIG. 5 LAYOUT OF STEEL CROSS GIRDERS IN A SPAN

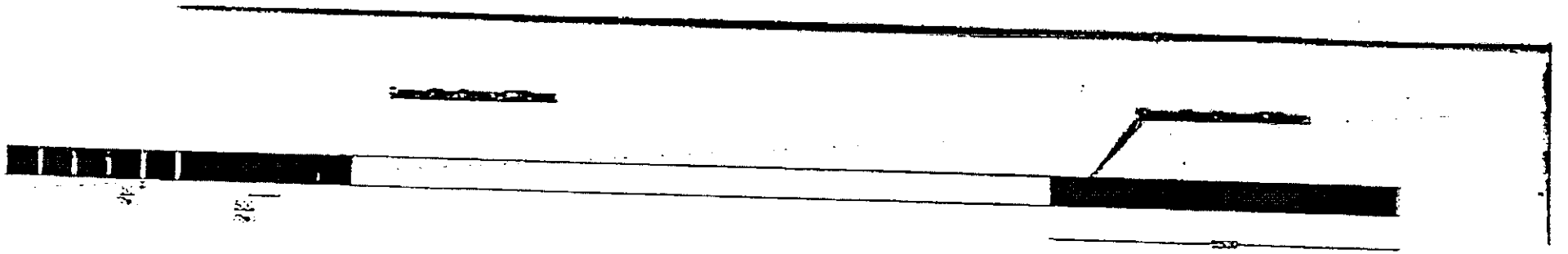


FIG. 3 LAYOUT OF CARBON FIBER FABRIC IN A GIRDER FOR SHEAR STRENGTHENING

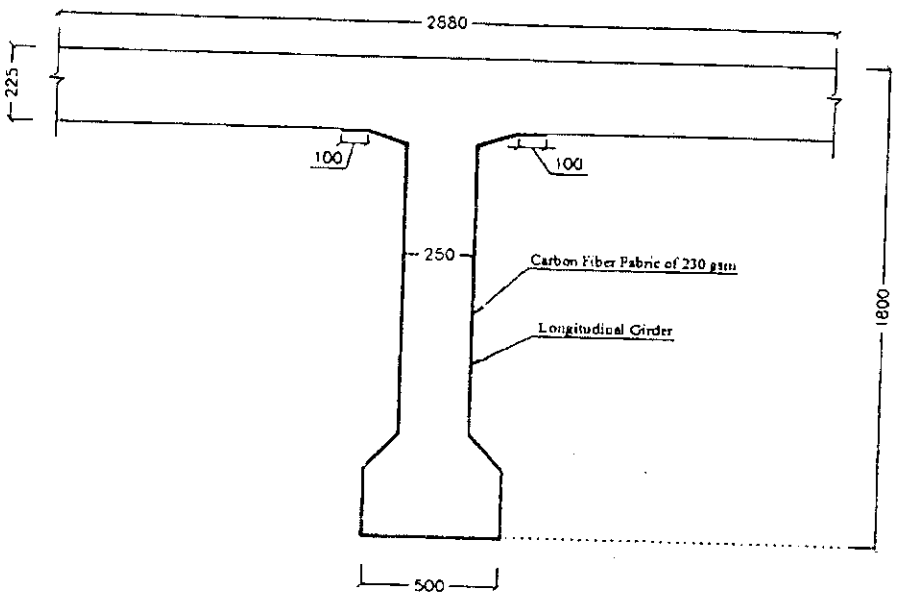



FIG. 4 BONDED CARBON FIBER FABRIC IN THE CROSS SECTION OF A GIRDER

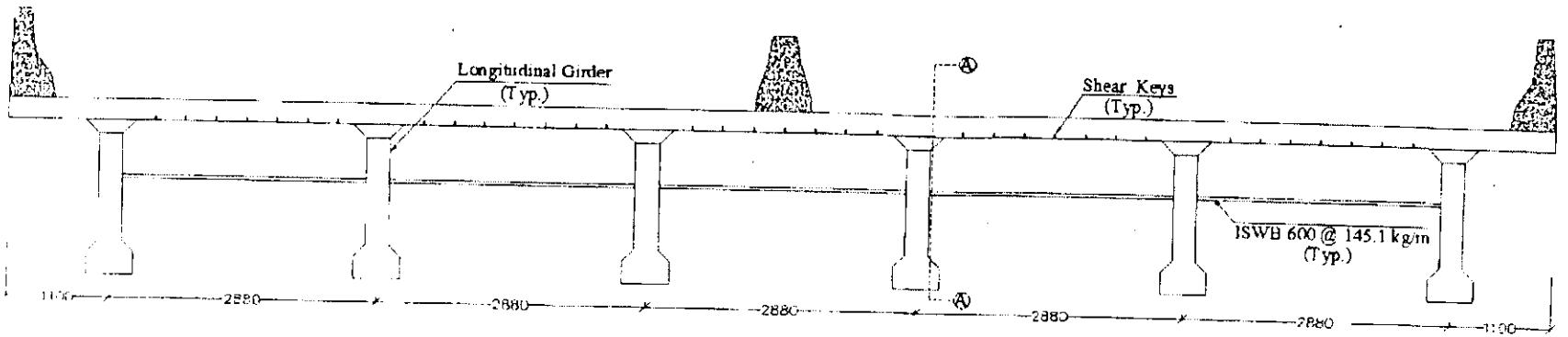
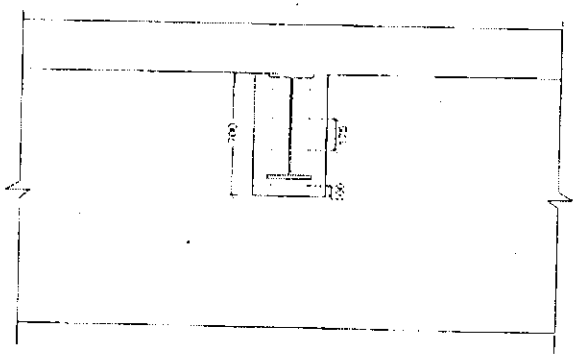



FIG. 6 POSITION OF STEEL CROSS GIRDERS IN BETWEEN THE LONGITUDINAL GIRDERS



Cross Section at AA

FIG. 7 CONNECTION DETAILS OF STEEL CROSS GIRDERS WITH PRECAST RC GIRDERS

## 5.0 FLEXURAL STRENGTHENING OF PRECAST RC GIRDERS BY CONCRETE JACKETING

The bottom cover concrete (50 mm thick) on RC girders shall be removed and cleaned from loose materials. 4 nos. 32 mm dia. TMT steel rebars shall be added as additional reinforcements to the existing reinforcements using U shaped shear keys of 10 mm dia. at a spacing of 200 mm c/c. Water tight shuttering to be provided and microconcrete shall be poured. Bottom shuttering shall be removed after 7 days. Proper curing to be done as per the manufacturers catalogue for microconcrete. The schematic diagram of concrete jacketing is shown in Fig. 8.

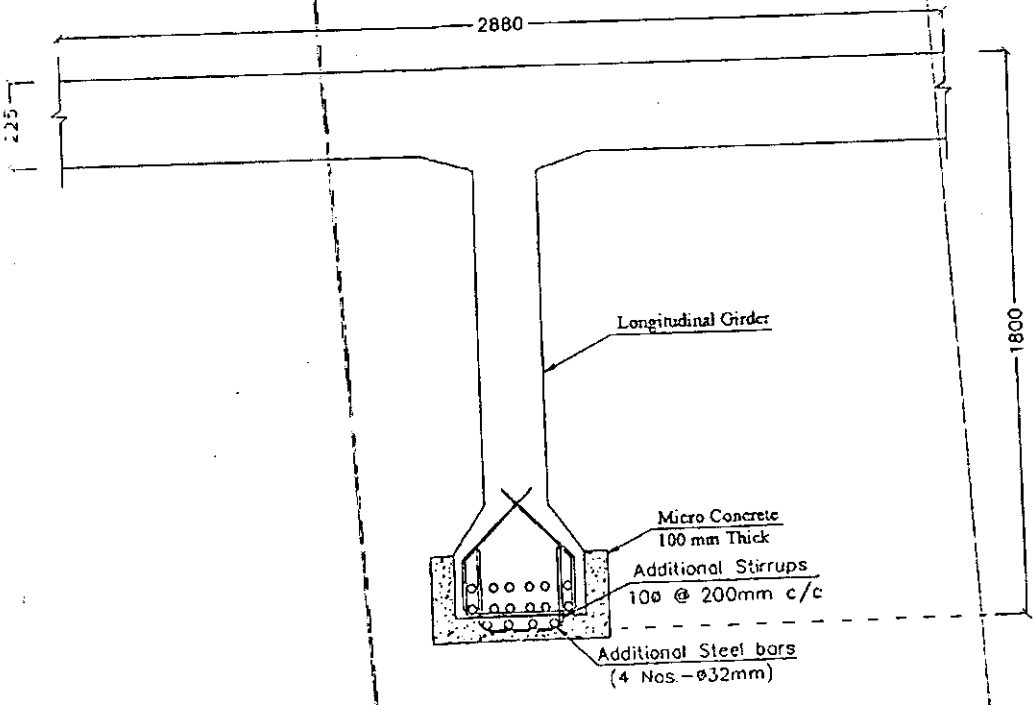



**FIG. 8 FLEXURAL STRENGTHENING OF GIRDERS BY CONCRETE JACKETING**

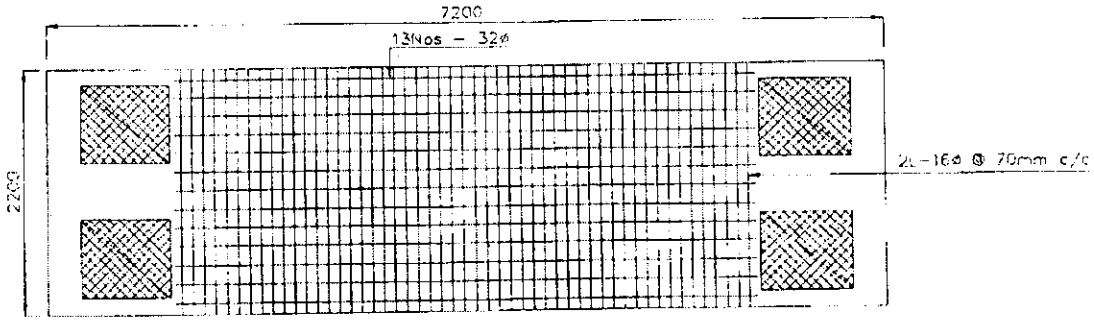



FIG. 9 ADDITIONAL STEEL REINFORCEMENTS AT THE TOP OF PIER CAP

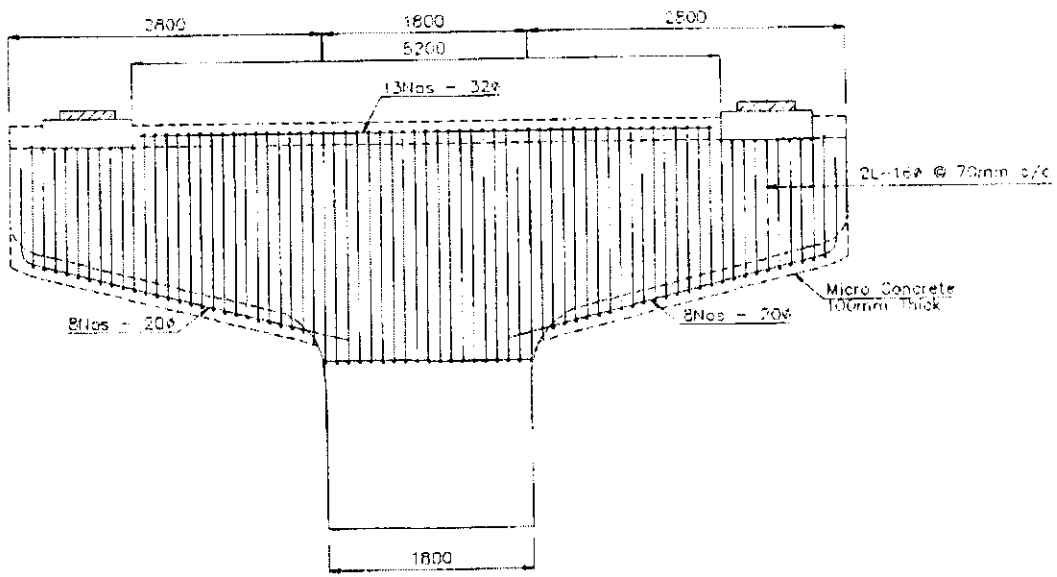



FIG. 10 ADDITIONAL STEEL REINFORCEMENTS AT THE BOTTOM OF PIER CAP AND STIRRUPS

## 6.0 REPAIR AND STRENGTHENING OF PIER CAPS

The concrete substrate around the pier caps and on the top in between the pedestals have to be roughened using any suitable scarifiers. The loose concrete if any to be removed and the roughened surface be cleaned. 150 mm deep holes have to be drilled at a spacing of 350 mm c/c and 6 mm dia., 200 mm deep resin injection nozzles to be fixed using epoxy putty on the cracks. Low viscous epoxy vinyl ester resin has to be pumped under pressure till refusal. All resin injection nozzles have to be cut and sealed with epoxy mortar.

13 nos. of 32 mm dia. TMT steel bars of length 5.2 m have to be added with the existing main reinforcements on the top of the pier cap by tack welding with the existing stirrup reinforcements. 8 nos. of 20 mm diameter bars of length 7.4 m have to be added with the existing main reinforcements on the bottom of the pier cap by tack welding with existing stirrup reinforcements. 2 legged 16 dia. stirrup reinforcements at a spacing of 70 mm c/c to be added on the pier cap above the additional main reinforcements. The stirrups on the additional steel reinforcement on the stem portion have to be anchored to the stem at both ends. After fixing all additional steel reinforcements on the pier cap in order, water tight shuttering has to be provided all around the pier cap. Microconcrete upto 100 mm thick has to be poured on the water tight shuttering. The shuttering has to be removed after three days. Proper curing has to be done as per the microconcrete manufacturers catalogue. The schematic diagram for repairing and strengthening of pier cap is shown in Figs. 9 and 10.

## 8.0 SUMMARY AND RECOMMENDATIONS

Based on the non-destructive and partially destructive tests and analyses, IIT Madras suggested to repair and strengthen the precast RC girders in seventeen standard spans and pier caps in eighteen piers P1 to P18. All precast RC girders to be strengthened for (i) flexure to enhance the effective moment of inertia and thereby reduce the deflection and (ii) shear to account for the increase in shear capacity due to flexural strengthening. The flexural, shear and flexural shear cracks on the girders to be arrested. The flexural and shear cracks in the Pier caps to be arrested. All Pier caps to be repaired and strengthened for both flexure and shear deficiency. The cracks on RC walls at the abutments to be repaired. The condition of pedestals and POT CUM PTFE bearings in the obligatory PSC girder (Center) span P9-P10 have to be checked and the pedestals to be repaired/recast and the bearings be replaced if needed.

IIT Madras explored the possibility of repairing and strengthening the precast RC girders using (i) Concrete jacketing, (ii) Steel jacketing, (iii) External flexural strengthening using CFRP composite pultruded sheets, (iv) Strengthening of girders by near surface mounting (NSM) technique using CFRP composite pultruded sheets, (v) Strengthening of girders by NSM technique using pultruded CFRP composite rebars and (vi) Shear strengthening using carbon fibre fabric composites. The possibility of repairing and strengthening the Piers using (i) Carbon fibre fabric composites and (ii) and Concrete jacketing are also explored. Considering the durability, cost and time to repair and strengthen the precast RC girders the following repair and strengthening scheme is recommended by IIT Madras:

8.1 Repairing of cracks in precast RC girders and pier caps by injecting low viscous resin,
8.2 Flexural strengthening of precast RC girders by concrete jacketing,
8.3 Shear strengthening of precast RC girders using carbon fiber fabric composites,
8.4 Cross stiffening of precast RC girders using standard steel sections and
8.5 Repairing of cracks on RC walls in the abutments.

The total estimated cost for the above mentioned scheme is Rs. 7.31 crores. IIT Madras will issue the execution drawings as per the requirement. Scaffolding, water supply and power supply have to be provided as per the site conditions by RBDCK/RDS. After repair and strengthening a span and two pier caps, a load test to be conducted and the measured deflection can be checked with the allowable limit to ensure the safety of the bridge. Strict

## 7.0 COST ESTIMATE TO REPAIR AND STRENGTHEN THE FLYOVER

### 7.1 Cost Estimate to Repair and Strengthen using NSM Technique

TABLE 1. REPAIR AND STRENGTHEN USING NSM TECHNIQUE

| Sl. No. | Repair and Strengthening Item and Technique | Cost (Rs./Crores) |
|---|---|---|
| 1. | Flexural strengthening of RC girders using CFRP composite rebars | 4.61 |
| 2. | Shear strengthening of RC girders using carbon fibre wrapping | 1.48 |
| 3. | Cross stiffening of RC precast girders using standard steel sections | 1.20 |
| 4. | Repairing of cracks in the precast RC girders by resin injection | 0.28 |
| 5. | Repairing of cracks in the RC retaining walls at abutments | 0.10 |
| 6 | Repair and strengthening of pier caps including the cracks | 1.08 |
| | **Total** | **8.75** |

Total duration : 6 months

### 7.2 Cost Estimate to Repair and Strengthen Using Concrete Jacketing

TABLE 2. REPAIR AND STRENGTHEN USING CONCRETE JACKETING

| Sl. No. | Repair and Strengthening Item and Technique | Cost (Rs./Crores) |
|---|---|---|
| 1. | Flexural strengthening of precast RC girders by concrete jacketing | 3.17 |
| 2. | Shear strengthening of RC girders using carbon fibre wrapping | 1.48 |
| 3. | Cross stiffening of RC precast girders using standard steel sections | 1.20 |
| 4. | Repairing of cracks in the precast RC girders by resin injection | 0.28 |
| 5. | Repairing of cracks in the RC retaining walls at abutments | 0.10 |
| 6 | Repair and strengthening of pier caps including the cracks | 1.08 |
| | **Total** | **7.31** |

Total duration: 9 months

quality control to be ensured during repair and strengthening of the Flyover. All safety procedures for manpower and machines to be ensured by the Applicators.

(Dr. P. Alagusundaramoorthy)
03.09.2019

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## PALARIVATTOM FLYOVER.

I. Prof. P.Alagusundaramoorthy of IIT Chennai has sent his proposals dated 03.09.2019 for the repairs and rehabilitation of the RCC girders and pier caps of Palarivattom Flyover. Briefly the scheme consists of:-

| | | |
|---|---|---|
| 1. | Flexural strengthening of precast RC girders by concrete jacketing | 3.17 |
| 2. | Shear strengthening of RC girders using carbon fibre wrapping | 1.48 |
| 3. | Cross stiffening of RC girders using standard steel sections | 1.20 |
| 4. | Repairing of cracks in the precast RC girders by resin injection | 0.28 |
| 5. | Repairing of cracks in the RC retaining walls at abutments | 0.10 |
| 6. | Repair and strengthening of pier caps including the cracks | 1.08 |
| | **TOTAL** | **7.31** |

Time indicated for the repairs is 9 months.

An alternative of structural strengthening of RC girders using CFRP composite bars has also been suggested which would then cost 8.75 crores with a time frame of 6 months.

After carrying out the repairs what would be the residual life of the bridge has not been indicated.

II. IIT proposals suffer from the following drawbacks.

a) The cost of repairs appears to be underestimated. For example, repairing the cracks by resin injection is shown to cost only Rs.28.00 lakhs. This would certainly cost much more as 97 out of 102 girders have developed multiple cracks. Drilling for too many holes for resin injection may

further weaken the concrete whose strength is already low and uncertain.

b) Shear strengthening of RC girders using carbon fibre wrapping may not bring in the expected benefit as such wrapping does not confine the concrete. To my mind, if the parent material strength is less than the permitted limit, the wrapping may become a failure. In this case, carbon fibre wrapping alone may not give the required shear strength. The technology of carbon fibre wrapping is new to the country and its life expectancy is also uncertain. They have not mentioned anything about the protection needed for the carbon fibre wrapping since the resins are not stable against ultra violet exposure.

c) To make up the deficiency in surface reinforcement, nothing is mentioned in the report.

d) Only the bottom flanges of the RC girders are strengthened by 100mm micro concrete jacketing. The side concrete has no reinforcement shown. This may spall off after some time due to vibration.

e) Nearly 16 tonne weight is adding in each span for retrofitting scheme. This extra weight (approx. 3 tonne weight in one single girder) will create additional bending moment and shear force in existing distressed girders. Any increase in dead load is not desirable as the four piles in foundation are at their limits.

f) The concrete jacketing of pier heads has to be more robust to increase their structural strength.

g) Since the concrete used in the bridge is generally found weak, the stem of the piers has also to be jacketed by RCC. This has not been indicated nor its cost accounted for.

h) IIT scheme has not eliminated the expansion joints over the pier locations. The dynamic impact at these joints will therefore continue.

III. IIT has not indicated what would be the residual life of the bridge after repairs. Since the life expectancy of such a bridge is about 100 years, I am of the considered view that it is better to dismantle all the RCC girder spans and replace with pre-stressed girders as indicated in my earlier report dated 03.07.2019.

(Dr. E. Sreedharan)

14.09.2019