Strengthening At The Local Court Building Of Makasar Due To Errors In The Construction Stages On Rc Beam & Column Using Tyfo® Fibrwrap® System

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ABSTRAK

Local Court Building of Makasar was started the construction stages at 2008. In 2009 Department of Public Work conducted structural investigation on it structural members, The investigation result was founded the beam have poor of concrete strength. After compare several of strengthening methods, owner and consultant prefer to use Fibre Reinforced Polymer (FRP) to upgrade the rc structural member, Strengthening using E-Glass FRP under design calculation of Tyfo® Fibrwrap® Composite System to all the RC beam at 2nd until 4th floor with various layer. The result of In situ loading test in the end of project was shown that the maximum actual deflection = 0.945 mm and the allowable deflection = 3.11 mm which is profes that retrofitting with Tyfo able to increase existing capacity according to the design.

Kata kunci:
Strengthening,
GFRP,
Beams,
Loading test,
Deflection

1. Introduction

The New Local Court Building with 4 storey build beside the old one, this project to be part of Indonesia Law & Human Right Department development program to upgrade the Makassar Local Court function in order to increase the law serve to the Makassar resident

2. Background Of Project

The project of New Local Court of Makassar Started in Middle 2008 and Finish Plan at end 2009, The owner and Consultant make plan to construct structural part in prior and will be follow with architectural manner. During the structural construction stages, owner ask the Public Work Department to conduct structural investigations to the RC column, Beam and slab. And poor of concrete strength (Fc) founded at RC Beam, actual concrete strength less than 18 Mpa, the conclusion investigation result was the concrete strength unappropriate with Indonesia Building Code. Based on the structural investigation report of Public Work recommended to conduct strengthening on all of RC beam from 2nd storey to 4th storey to ensure the beam able to satisfied the load function of the building. They were given two option of strengthening method, Steel H-Beam and Fibre reinforced Polymer to cater live load 250 kg/m2 & Superimposed dead load 150 kg/m2.

After reviewing two methods proposed, strengthening using Tyfo® Fibrwrap® Composite System was chosen to upgrade this structure, By considering that Tyfo® Fibrwrap® Composite System offered design calculation, easier, quicker, reliable application and did not cause distress or add weight to the member to be strengthened.

3. Structural Investigation

Visual Survey

A Visual survey was conducted an the structural members of this building, Beam founded many structural defects such as spalled concrete, honeycomb and crack. (Fernanda, dkk. 2011)

Concrete Core Test

The coring locations were select from each structural members such as beam, column, slab and foundation. Sixteen
cores sample were then sent to the Public Work laboratory for visual examination, density and compressive strength test. (J.Y. Richard, et.al 2009)

<table>
<thead>
<tr>
<th>No</th>
<th>Structure Members</th>
<th>Concrete Strength Fc’ (Kg/cm2)</th>
<th>MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beam</td>
<td>174</td>
<td>17.4</td>
</tr>
<tr>
<td>2</td>
<td>Slab</td>
<td>282.5</td>
<td>28.25</td>
</tr>
<tr>
<td>3</td>
<td>Column</td>
<td>311.1</td>
<td>31.11</td>
</tr>
</tbody>
</table>

4. Repair And Strengthening

The result of structural investigation provide a reference of repair and strengthening implementation. The sequence of work based on the actual condition of RC beam.

Honeycombed / Spelled Concrete

Some of existing RC beam suffer honeycombed and spelled was removed until sound concrete was reached. And than where the depth of concrete removed did not exceed above 100 mm should be patching using bonding agent and polymer modified cementious mortar. If the depth of removed concrete exceed 100 mm using pressure grouting method.

Crack

All crack greater than 0.3 mm wide in the concrete were fill by pressure injecting low viscosity epoxy resin in a sequential manner along the crack length such that the epoxy resin filled the crack completely.

Strengthening

Reduction of concrete strength on the beams members make the existing capacity of the beam not satisfy the live load factor = 1.6, strengthening required on the positive moment, negative moment and shear.

Public work Department recommends strengthening method with Fibre reinforced Polymer (FRP) for retrofit the beam. (Cheng Chen, 2020)

Review to determine an appropriate strengthening method conduct by owner and consultant team.

Tyfo® Fibrwrap® Composite System selected for this strengthening method, with consider based on the own design calculation, advantageous and cost benefit. Tyfo® Fibrwrap® Composite System meets the demands of strengthening requirement for a lightweight, easily applicable, structurally powerful and reasonably budgets compare using of Steel I beam.

E-glass FRP Composite system under Tyfo® Fibrwrap® Composite System using for this RC beam retrofitting.

In ACI440-2R-2008, there are specific requirement to only allow for the use of system in strengthening application that are fully tested, certified and well-supported with test report, research papers and other relevant technical documents showing their effectiveness in structural strengthening.

The properties of the composite are governed by individual properties of the constituents. In particular, the properties of the unidirectional FRP are substantially higher in the longitudinal direction than in the transverse direction. It is the longitudinal properties of composites that are mentioned in this literature for comparative purposes. Properties of the E-Glass FRP Composite Systems that used in this project are summarized in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Tensile Strength (MPa)</th>
<th>Elastic Modulus (GPa)</th>
<th>Coefficient of Thermal Expansion (10^-6/C)</th>
<th>Ultimate Strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>575</td>
<td>26.1</td>
<td>7.74</td>
<td>2.2</td>
</tr>
</tbody>
</table>

The strengthening purposes on the beam was to satisfy the required shear, negative and positive moment. Shear capacities of the beam were enhanced by U wrapping on the end span of the beam with the primary fibre oriented essentially perpendicular to their axes. The negative moment capacities of the beam were enhanced by orienting the primary fibres of the composite on the top of end-span of the beam parallel to their longitudinal area.

Figure 1. Typical Strengthening for Negative Moment

The positive moment capacities of the beam were enhanced by orienting the primary fibre of the composite on the bottom mid-span of the beam parallel to their longitudinal area.

Figure 2. Typical Strengthening for Positive Moment

The strengthening design computed based on ACI 440-2R-2008, the strengthening design must satisfy the requirement of strain compatibility and force equilibrium with consideration of tensile force contributions from the post tensioned tendons, the steel reinforcement and the FRP strengthening system.
5. In-Situ Load Test

Purpose of the loading test were to determine the beam capacity after strengthening using Glass FRP.

The targeted Loading test is based on the actual design live load of 250 kg/cm². Loading of water was used as shown in figure 5.1 with load combination:

\[ P_{\text{test}} = 0.85 (1.4 \text{ DL} + 1.7 \text{ LL}) - \text{Existing DL} \]

Note:

- \( P_{\text{test}} \) = Load Test
- \( \text{DL} \) = Dead Load
- \( \text{LL} \) = Live Load

The dial gauges were positioned at 3 different location at the beam to capture the deflection of strengthened beam throughout the entire load test (Peng Pan, 2013).

<table>
<thead>
<tr>
<th>Phase No</th>
<th>Phase</th>
<th>Time</th>
<th>Load</th>
<th>Weight (Kg/m²)</th>
<th>Water Depth (cm)</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>175</td>
<td>17.5</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>350</td>
<td>35</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>525</td>
<td>52.5</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>700</td>
<td>70</td>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>350</td>
<td>35</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>

When the beam receive maximum load 700 kg (Water Depth = 70 cm), deflection that occur 0.945 mm less then allowable deflection 3.11 mm

<table>
<thead>
<tr>
<th>Dial No.</th>
<th>Dimension (cm)</th>
<th>Max Deflection (mm)</th>
<th>Rebound (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>L</td>
<td>Max Actual</td>
<td>Allowable</td>
</tr>
</tbody>
</table>
6. Conclusion

The strengthening of the RC Beam in this project was successfully implemented using Glass FRP Composite System. The in-situ load test result was shown the strengthening system successfully satisfying the acceptance in the code of practice.

References

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