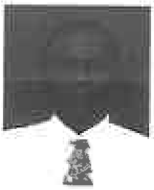
IMPACT OF ADHESIVE THICKNESS ON THE CAPACITY OF THE SURFACE MOUNTING STEEL PLATES STRENGTHENING TECHNIQUE

Akinropo Olajumoke
Civil Engineering Science Dept., University of Johannesburg, Johannesburg, South Africa.



Akinropo Olajumoke is currently a doctoral candidate in Structural Engineering. His research interests are in reinforced concrete and composite structures as well as in materials of construction.

Morgan Dundu
Civil Engineering Science Dept., University of Johannesburg, Johannesburg, South Africa.

Morgan Dundu is a Professor of Structural Engineering and Vice Dean (Teaching & Learning) of the Faculty of Engineering and the Built Environment, at the University of Johannesburg. His research interests are in cold-formed steel and composite structures.

EXTENDED ABSTRACT SUMMARY

This study investigates the adhesive thickness that can achieve maximum composite action between the concrete and steel plate. To accomplish this, rectangular concrete blocks were cast, cured and scabbled, while steel plate strips were sandblasted, and variables in the tests were restricted to epoxy and steel plate thicknesses. After bonding the steel plates to the concrete, a load was applied on the concrete blocks, to induce direct shearing force on the steel plate-epoxy-concrete interface. Despite the different plate thickness, the steel plates did not yield at the failure of the double lap arrangement. Failure occurred by a combination of plate separation and rip-off of concrete with the steel plates. Based on the shear forces attained, it is recommended that a 1.5 mm thick adhesive be used to bond the steel plates to the concrete elements, in bending.
Keywords: Steel plates, epoxy, reinforced concrete, strengthening, scabbling, sandblasting, debonding

INTRODUCTION

The techniques of strengthening existing reinforced concrete (RC) elements, in bending, with steel plates have attracted the attention of many researchers in the last five decades. However, improper preparation of the concrete surface and incorrect thickness of the adhesive can lead to premature failure or debonding at the adhesive-concrete interface. According to Olajumoke and Dundu [1] the common failure modes reported in literature are plate-end debonding, delamination/rip-off and intermediate crack debonding [2, 3]. Establishment of adhesive thickness for maximum composite action will ensure economic use of the epoxy with enhanced load carrying capacity of RC elements in bending.

SPECIMENS PREPARATION AND TESTTING

Steel plates, size 100 by 500 mm, were drilled with 2, 20 mm holes, at 100 mm centres at the unbonded end, in order to secure them on the testing frame. Later, one side of the steel plates was sandblasted to remove the oxide layer and roughen the surface. The opposite sides of the rectangular concrete blocks were scabbled with tungsten carbide tipped cruciform three-piece head pneumatic machine, which had low impact effect on the concrete blocks without causing any crack to it. The scabbling was done to an average depth of 2 mm to remove weak laitance concrete and to uniformly expose the aggregates for better adhesion and interlocking between the epoxy and the concrete. Then, the surface was wire-brushed and high pressure air blown over the surface to remove the grits and dust. Thereafter, application and gluing of the plates to concrete and testing of composite specimens were carried out.

ANALYSIS AND DISCUSSION OF RESULTS

The summary of the failure loads, displacement and shear stress resulting from the maximum failure loads are given in TABLE. Generally, it can be observed that irrespective of the steel plate thickness, the 1.5 mm epoxy thickness sustained the highest load followed by 5 mm and then 3 mm epoxy thicknesses. Based on this, it is recommended that 1.5 mm epoxy thickness be used in steel plate strengthening of RC elements for efficiency and economy. The shear stress on each face of the concrete blocks due to the maximum failure load is calculated from equation (1).

$$\tau_{ave} = \frac{P}{2A_b} \tag{1}$$

Where:

τ is shear stress (N/mm^2), P_{max} is maximum failure load (kN) and A_b is bonded area (mm).

Table 1: Failure load, shear stress and displacement of the tested specimens

Specimen	Failure load (kN)	Vertical displacement (mm)	Shear stress on bonded face (N/mm^2)
SP4-1.5	233.258	16.5	3.89
SP4-3	186.924	17.5	3.12
SP4-5	189.660	17.0	3.16
SP6-1.5	228.446	17.3	3.81
SP6-3	185.716	20.0	3.10
SP6-5	184.062	16.9	3.07
SP8-1.5	210.540	17.2	3.51
SP8-3	197.293	18.4	3.29
SP8-5	206.071	16.6	3.44

CONCLUSIONS

Based on this study, the 1.5 mm epoxy thickness supported the highest axial load at failure. Hence, it is recommended for use in the surface mounting steel plate (SMSP) strengthening techniques of structural RC elements in bending. The failure modes were a combination of plate separation and rip-off of concrete with steel plates. For effective and full composite actions, there is need to apply adequate force on the steel plates against the concrete elements until the epoxy properly sets and hardens.

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