A Novel Method for Interfacial Stress Analysis of Plated Beams

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Introduction
Recent developments in structural engineering have demonstrated the effective enhancement in strength and performance of reinforced concrete and metallic beams bonded with a thin fibre reinforced polymer (FRP) composite or steel plate on its tension face (Fig. 1). This technique is now popularly adopted for retrofiting existing structures. Interfacial shear and normal stresses are developed between the adherents in such plated beams during the transfer of stresses between the bonded plate and the original beam. The combination of these stresses are responsible for the common premature debonding failure of the plate from the original beam in a brittle manner.

Consequently, many analytical solutions have been developed to quantify these interfacial stresses. However, almost all these solutions are specific to pre-defined simple loading arrangements, so each solution is only applicable to a specific loading. This research presents a new analytical solution for the interfacial stresses in simply supported beams bonded with a tension face thin plate. The solution is generic and applicable to beams and plates made of any materials within the linear elastic range which is common to almost all previous studies. The novelty of this work lies in the application of the superposition principle so that the simple solution is applicable to any arbitrary loading arrangement.

Methodology
The plated beam under an arbitrary loading as shown in Case-1 is split into Case-2 and Case-3. Case-2 includes all the external loading plus an axial force and bending moment at each end of the plate. The magnitude of these axial forces and moments are determined from the deformation of the un-plated beam so that both ends of the plate deform compatibly with the un-plated beam under the external loading and the case can be analysed using the classical composite beam analysis. Case-3 is the plated beam under the same but opposite plate end loading as in Case-2.
Case-3 is further decomposed into a symmetrical loading Case-4 and anti-symmetrical loading Case-5 within the plated region. The combined solution to Cases 2, 4 and 5 gives the solution for the original problem Case-1.

Solution
1. Interfacial shear stress
\[ \tau(x) = m_y(x) V_{y}(x) \]
where
\[ m_y(x) = \frac{Q(x)}{L_b} \]

2. Interfacial normal stress
\[ \sigma(x) = c \]

3. Solution to Case-1 = Solution from Case-2 + Case-4 + Case-5

References