DEVELOPMENT OF A HYBRID ANALYTICAL-NUMERICAL PROCEDURE AND NEURAL NETWORKS FOR COMPOSITE STRUCTURES SUBJECTED TO SERVICE LOAD

By

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CERTIFICATE

This is to certify that the thesis entitled, "**Development of a Hybrid Analytical-Numerical Procedure and Neural Networks for Composite Structures Subjected to Service Load**" being submitted by **Sandeep Chaudhary** to the Indian Institute of Technology, Delhi for the award of the degree of **Doctor of Philosophy** is a bonafide record of research work carried out by him under my supervision and guidance. The thesis work, in my opinion, has reached the requisite standard fulfilling the requirement for the degree of **Doctor of Philosophy**.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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(Sandeep Chaudhary)

ABSTRACT

There has been an increasing use of steel concrete composite construction in recent years owing to complementary nature of inherent advantages of steel and concrete as building materials. The concrete portion in the composite structures cracks, in the regions of tensile stresses, on the application of load if the tensile stresses exceed the tensile strength of the concrete. This results in force redistribution and change in deflections. The time-dependent effects of creep and shrinkage in the concrete may lead to further progressive cracking, force redistribution and change in deflections. The appropriate analysis of the composite structures, subjected to service load, taking into account the cracking, creep and shrinkage of concrete is therefore important. Of the two categories of methods available in the literature for the analysis at service load stage, numerical methods require huge computational effort whereas analytical methods do not take into account all the aspects.

Therefore, a highly efficient hybrid analytical-numerical procedure has been presented in this study for the analysis of composite beams and frames subjected to service load, taking into account the cracking, creep and shrinkage in concrete. The procedure is analytical at the elemental level and numerical at the structural level. Cracked span length beam elements have been utilized in the proposed procedure. Closed form expressions for crack lengths, flexibility matrix coefficients, end displacements and mid-span deflection of the cracked span length beam element have been presented which can be utilized for generation of stiffness matrix and load vector. The proposed procedure has been validated with experimental and analytical results available in the literature and with finite element analysis results. The computational effort required for the proposed procedure is shown to be a small fraction of that

required for finite element analysis. Systematic behavioral studies are also reported for continuous composite beams and frames using the proposed procedure.

Further, a methodology has been presented for predicting the instantaneous behavior of composite beams using neural networks. The methodology would be very useful in rapid prediction of effects of concrete cracking in composite structures at the planning stage. Nine significant structural parameters have been identified which govern moment redistribution at the supports and change in mid-span deflections of a span due to cracking of concrete. Based on the methodology presented, considering cracking of concrete, six neural networks each for prediction of instantaneous moments and instantaneous mid-span deflections have been presented. The huge data required for training of networks is generated using the proposed procedure. The neural networks have been validated for a number of beams.

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