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Investigation of nodal coupling of reinforced concrete column and floor in buildings with monolithic assembly framework by ANSYS

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Abstract. The ANSYS software and computer system is used to investigate the work of the nodal joint of the reinforced concrete column and the slab of the frames of residential buildings. It is proved that modeling of the assembly-monolithic frame unit with the help of the automated design system is the most rational way to solve the problem of increasing the safety of the node reinforced concrete joints.

1. Introduction

Experience on examination of buildings and structures with the use of the assembled-monolithic framework, and theoretical studies in the field of reinforced concrete structures [1] have shown that node interfaces are the most vulnerable elements of framework systems. Due to the fact that works on reinforcement and concatenation of units are carried out already on the site and often with improper quality control, various kinds of defects may appear (Figure 1). Thus, the main justification for the study of the nodal coupling is the characteristic appearance of deformations due to cracking formation in the support zones and washing of concrete . on contact surfaces. In Figure 2 it is possible to note characteristic inclined cracks.

Figure 1. Crack opening in the pre-support zone

Figure 2. Opening of inclined cracks in the pre-support zone

The fact that the works on the arrangement of the units can be performed in a poor manner entails possible defects that exclude the joint operation of concrete and reinforcement (Figure 3).

Figure 3. Non-concrete areas detected during the survey

In addition, it should be noted that the physical and structural nonlinearity of these areas is most evident in the assemblies of monolithic frames. The degree of compliance varies depending on the stress-strain state, which invariably results in a substantial redistribution of effort.

2. Results and discussion

Nowadays the existing methods of calculation do not fully take into account the influence of compliance of node interfaces on the joint operation of structural subsystems of the framework - longitudinal and transverse frames, floor discs and stiffening membranes. This is mainly due to insufficient study of spatial interaction of monolithic elements in both their stages of operation, elastic and plastic. Therefore, as a rule, calculation of frame buildings is carried out according to design schemes with hinged or rigid assemblies of element interfaces, which can not fully reflect the operation of bearing structures.

Modern requirements for economic efficiency of made design solutions entail inevitable refinement of design models of node interfaces of structures of prefabricated-monolithic frame buildings [2].

One of the rational ways to solve the task is to model the assembly-monolithic frame assembly using the automated design system.

The node is modeled in stages using AutoCAD tools and then imported into ANSYS. This clearly illustrates the Design Interface Node process on-site and is the first step in refining the node model implemented in SCAD.

Rigidity of the unit is provided by passing horizontal reinforcement bars through the column body with subsequent joint grouting. This type of coupling allows to reduce span bending moment due to its redistribution to support moment, which leads to reduction of reinforced concrete flow rate. The entire frame is assembled without welding, which improves the quality of the work and the overall reliability of the assembly.

The initial data for loading are data obtained as a result of calculations in the SCAD software system and are implemented in three stages: through collection of loads on the scheme fragment – overlap – by conversion of internal forces of the crossbar and in the form of load from the floor structure and payload. H is selected as output units for an easy load transfer to ANSYS; for load from the floor structure and payload - i.

Loading is formed by a multicomponent in the range from 0 s to 1 with a uniformly increase to a full magnitude. Such method allows one to achieve more convergence of nonlinear calculation and in general to simplify the solved problem. Because the axes in SCAD and ANSYS do not match, the loads are named with reference to SCAD. Loading for the monolithic plate and formwork plates is formed by loads in SCAD design scheme nodes divided by the surface area of the selected elements face.

The movement of the model in space is constrained by 14 rigid links on the surfaces of the cut faces of the column and its rebar, bottom and top.

Among other things, at the first stage of the analysis, all bodies of the system are assigned contacts on bonded surfaces. These contacts are linear and function as absolutely rigid. The assembly will thus operate as a monolithic structure.

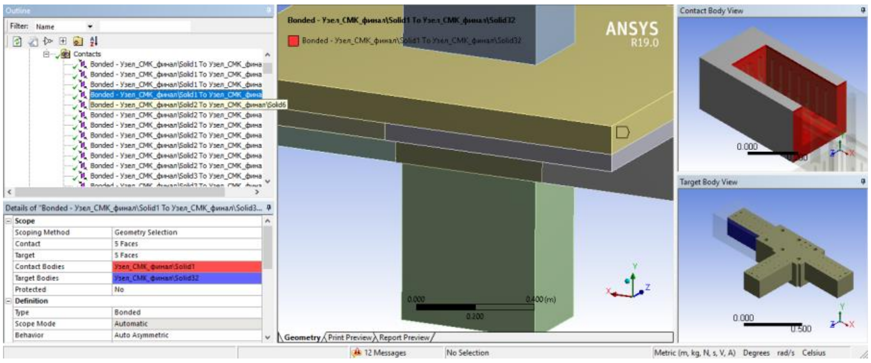

Figure 4. Connections by concrete contact surfaces

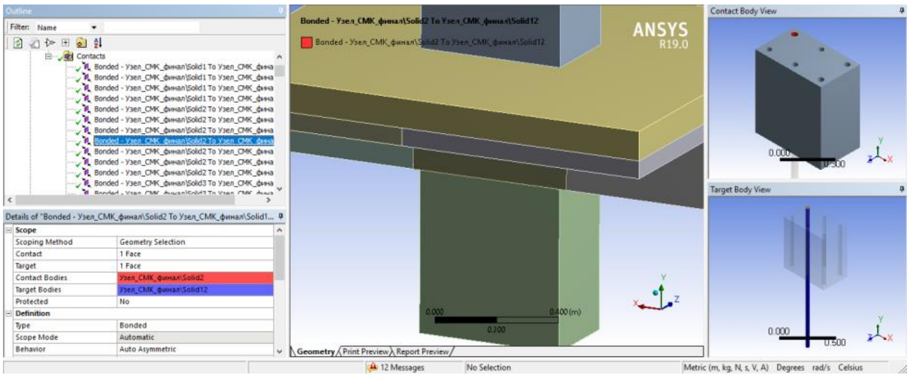

Figure 5. Connections on contact surfaces of concrete and reinforcement

The finite element model grid is set adaptively prior to square elements. The size of the end element is 0.05 m.

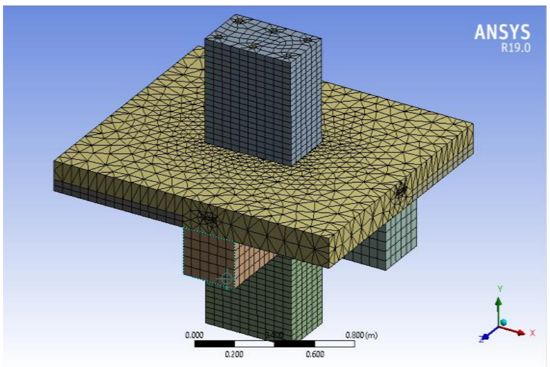

Figure 6. Finite element model of nodal interface

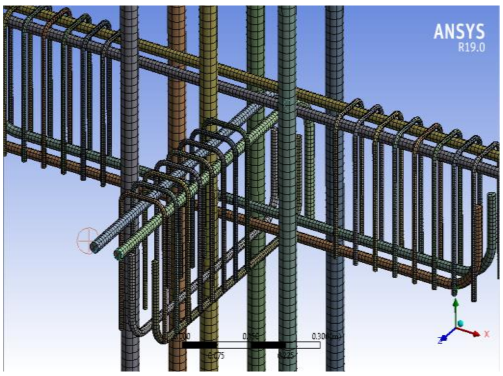

Figure 7. Finite element reinforcement model

In the contact areas of different elements in the grid, a more dense structure is organized to achieve greater convergence (Figure 8).

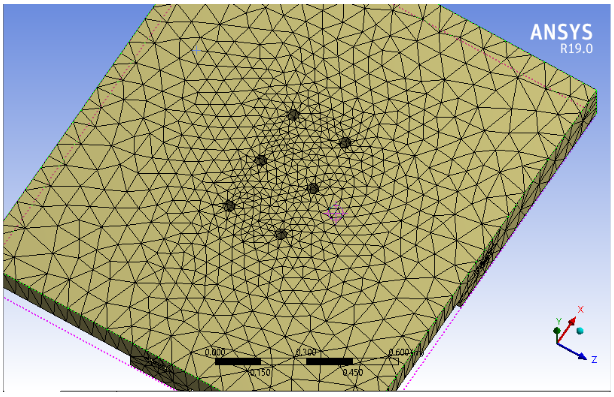

Figure 8. Grid of the 2nd monolithic layer

Materials for linear calculation are specified on the basis of density, limit strength characteristics and parameters of isotropic elasticity - modulus of elasticity and Poisson coefficient.

Additional materials have been created for nonlinear calculation: steel, whose strength parameters describe a bilinear isotropic hardening diagram, and concrete, whose behavior is described by the Menetrey-Willem model. The selected model in particular allows the dilatancy angle parameter to be used, thereby making the transition from an ideal elastic-plastic material to a more real one (Figure 9).

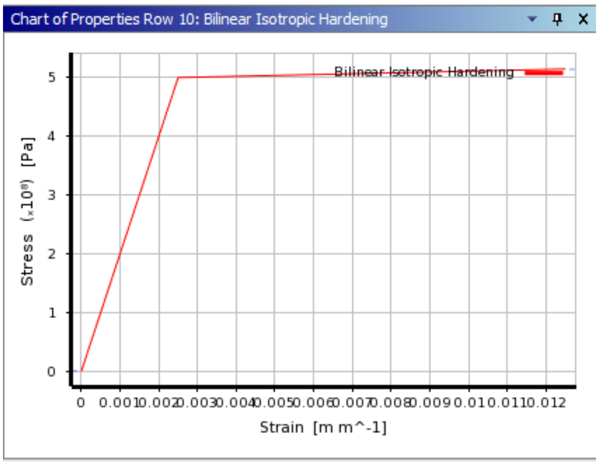

Figure 9. Schedule of bilinear hardening of steel material A500C

Within the calculation, equivalent stresses in concrete and reinforcement are established and the degree of deformation of the model under load is determined.

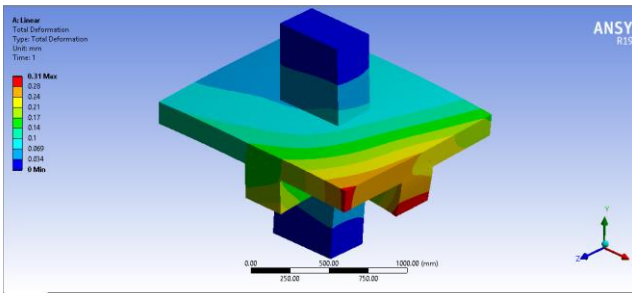

Figure 10. Deformation diagram

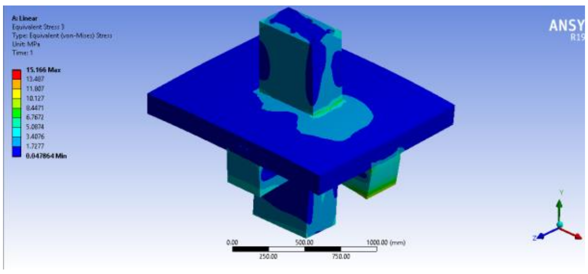

Figure 11. Equivalent stresses in concrete

As can be seen from the figure, the pre-support zones are indeed most prone to cracks.

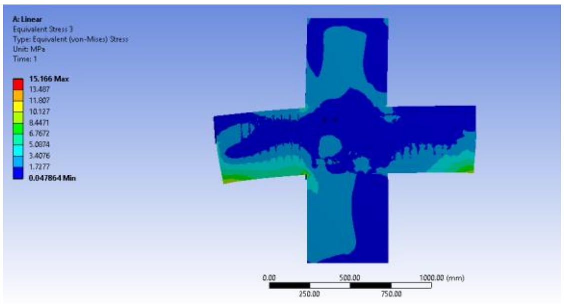

Figure 12. Equivalent stresses in concrete (section)

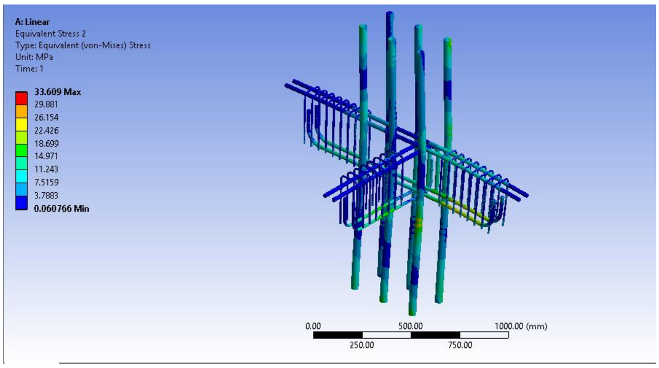

Figure 13. Equivalent stresses in reinforcement

3. Conclusion

The obtained isofields of stresses allow one to conclude that the transition to the refined nonlinear model allowed more accurately determining the points of stress concentration in the tested node.

The model of this kind will make it possible to predict the possibility of disruption of joint operation of reinforcement and concrete, absence of adhesion or its insufficiency for monolithic layers of concrete and adjacent prefabricated structures. However, such a model remains idealized in some ways, as it does not take into account the possibility of changing the friction coefficient during operation or testing of the assembly. Such a problem can be solved by command input of parameters of change of friction coefficients for specified bodies, but still for accurate assessment of operation of the assembly-monolithic unit it is necessary to carry out experiments

Acknowledgments

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