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Analysis and Design of a High-Rise Reinforced Concrete Structure

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Summary

The structure of a tall building, which is aimed to be a hotel with restaurant and casino, is considered in this paper. This structure is under construction in Moscow and is going to be high 106m, with 34 stories. The floor plan of higher part of the structure is in the shape of rectangle of size 36.00m x 17.40m. The analysis of the structure as a spatial one, by use of the first order theory in accordance with Russian code, as well as the analysis of representative frames in two orthogonal directions is carried out. The mathematical model consists of 918 joints and 2298 members. A new software package for static analysis, as well as dynamic analysis, based on the response spectrum analysis of the earthquake engineering, with comprises interaction of the structure and soil, is developed.

1. Structure concept

Hotel "Centrosojuz" is going to be high-rise building with restaurant and casino. It is under construction in Moscow and is going to be high 106m. The floor plan of higher part of the structure is in the shape of rectangle of size 36m x 17.40m. Structure of this building is designed as reinforced concrete structure, composed of concrete and high-quality steel. The caring system is spatial, mixed one, and it consists of columns, beams and plates. The structure is design according to IMS (Serbian Institute for Materials) precast prefabricated reinforced concrete system, which is widely applied all over the world (Yugoslavia, Hungary, Russia, Cuba, India, i.e.). IMS system is proved for 30 stories. As this hotel is planed with 34 stories, designer has predicted nine stories as monolithic, reinforced concrete, casted at the site (two of them are cellar under ground), while the other 25 are precast prefabricated. In the case of tall buildings torsion imperfection increases with increasing of the number of stories. It is necessary to pay attention on this effect in designing, as in the case of structure that is object of this paper.

The transmission of vertical load is performed by two-way slabs on longitudinal and transversal beams of the frames and finally on vertical caring elements of structure.

Reinforced concrete wall-plates in transversal direction at the ends of structure, as well as reinforced concrete core in the zone of elevator are to accept wind forces. Those elements and columns carry vertical load as well.

2. Analysis of loading

Loading is analyzed in accordance with Russian code SNiP (Stroiteljne Norme i Pravila), which consider separately weight of the structure itself and long-term vertical useful movable load (about 30% of the whole load) and whole useful load. Horizontal wind load contains of two components: static and dynamic action

3. Static and dynamic design

A new software package, similar to STRESS, is developed by use of Finite element method for purpose of static and dynamic design, which comprises the interaction of the structure and soil. The static analysis of the structure as a spatial one, by use of the first order theory in accordance with Russian code, as well as the analyses of the representative frames in two orthogonal directions, is carried out. The mathematical model consists of 918 joints and 2298 members.

Interaction between foundation structure and soil is taken into account by assuming that slab foundation is boundless rigid and placed in an elastic soil. Data about soil properties are taken from available geomechanics report.

The adopted simplified dynamically model is cantilever beam with masses in the level of the floors. Such model is chosen because static model with 918 joint and 2298 members is to complicated for dynamic analysis.

Reinforced concrete foundation plate is design by means of Finite element method as plate on elastic foundation using nodal points as boundary elements.

All calculations are carried out for five types of loading and appropriate superposition:

1. weight of structure itself;
2. vertical long-term useful load;
3. whole vertical load;
4. wind load in longitudinal direction;
5. wind load in transversal direction.

4. Proportioning

Three programs in FORTRAN are developed for the porpoise of proportioning of the structure elements, as are floor plates and foundation plate, beams and columns of frames.

According to mentioned Russian code for concrete and reinforced concrete the two phases are required:
- I - design of caring capacity and stability of structure;
- II - design for serviceability phase.

5. Conclusion

Design concept that is presented in this paper is proved by numerical results. Our experiences point out that IMS system is rational, economical and constructively safe enough for high-rise structures. In the case of tall buildings torsion imperfection increases with increasing of the number of the stories and that why it is necessary to pay attention on this effect in designing as it is in case of the structure which is object of this paper. Such structures can be recommended for application because they are very economical, not expensive and fast for construction.