EARTHQUAKE RESISTANCE OF PRESTRSSED REINFORCED CONCRETE AND CONVENTIONAL STRUCTURES

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SYNOPSIS

The paper deals with experiments carried out in Kazakh State Industrial Building Design and Scientific Recearch Institute to prove the earthquake resistance of frame and large-panel buidings made of precast reinforced concrete structures and the evaluation of their earthquake resistance. The investigation of building response for dynamic effect was made during their forced vibrations simulated by vibration generator,high frequency microseisms,powerful subsurface blasts,natural earthquakes,free vibrations after instant release of load and the data obtained from strong earthquake after-effects.

INTRODUCTION

Precast reinforced concrete structures are quite earthquake resistant as proved by experimental investigations and observations of their behaviour during earthquakes,provided they had been properly designed and made.

1.It has been experimentally proved that dynamic rigidity of multistoried frame buildings in elastic stage of their work appeared to be substantially (2-4 times) greater as compared to its design values. Such discrepancy of design and experimental period values testifies to a certain influence of structural members that fill in the frame (staircases,partitions,shed panels etc.) on the general rigidity of multistoried frame buildings. Quantitative data have been obtained that characterize the influence of wall filling such as: partitions and shed panels on the general building rigidity. For pure frame deprived of any filler, the existing design technique for determination of dynamic features are very close to the data obtained.

The behaviour of structures at the stage near the limits is not yet completely studied. To check and substantiate the methods of design for existing buildings several fragments of such buildings were tested.

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A section of one-story frame building of Alma-Ata textile factory with dimentions in the extreme columns' axes being 24 x 36 m (fig.1) and two natural fragments of four-storied large-panel building on continous and pile foundations were tested for the effect of horizontal static and dynamic loading. Dynamic effect was simulated by synchronous instant release of horizontal load by means of special mechanical device equipped with electromagnetic remote control. Dynamic effects for the fragments of a large-panel building were also produced by vibration generator. A large-panel building on pile foundation was tested by two stages. Exiting inertious load was transmitted to the object throuth the ground and was placed on the roof of the building. It was determined that vibration periods of investigated object increased with the increase of loading.With increase of exiting load by 2.5 times,the free vibration period of a fragment of a large-panel building on pile foundation increased by 1.5-1.7 times dependingon technique of load application. It is notable that the increase of pliability of pile foundation is increased with load.

2. The behaviour of modern eartquake resistant buildings with bearing structures made of precast reinforced concrete and also brickwork was studied for the first time under seismic conditions close to the natural ones which were created by means of powerful blasts during erection of artificial antisilt Medeo high dam. Six test buildings were specially built and tested at the distance of 800 m from blast center where magnitude 7-8 (MSK-64 Scale) "earthquake" was expected(fig.2). The maximum acceleration value and soil displacement registered during the blast were respectively 500 cm/sq sec and 9 mm.

All the buildings under test were vibrating during the blast practically with the same forced vibration frequency of 2.5 cps which was equal to soil vibration frequency. The results of this unique experiment allowed to make spontaneous comparison between the earthquake resistance of brick,large-panel and frame buildings. Brick buildings with reinforced concrete inclusions designed for magnitude 9 (MSK-64 Scale) earthquake had the maximum damages due to considerably less resistance to dynamic effects as compared to frame and box-shaped structutes made of precast reinforced concrete. The typical feature for all the buildings was the decrease of damage effect with increase of floor number The lower floors experienced more damage that may be evidently accounted for considerable magnitude of vertical displacement component near building foundation (8.2 mm) which influenced on its rigidity.

3. On May 10,1971 an earthquake occured in Kazakhstan with epicentre as far as 8-12 km to the south from Dzhambul City and magnitude 5.5 (Richter Scale),the heath's

depth being 15-20 km. This earthquake appeared to be the most distructive one for buildings with rigid structural scheme and particularly for low buildings. The lower floor of multistoried buildings have undergone more damage which gradually decreased with height. This mode of damages had full analogy with those observed during tests at Medeo, where blast earthquake had magnitude for about 7(MSK-64 Scale). Dzhambul earthquake was rather notable fact. Practically the majority of modern buildings which were designed for magnitude 7 (MSK-64 Scale) earthquake had notable signs of damage since the intencity of earthquake corresponded to that adopted in design or was near to it.The data obtained from eathquake analysis proved a rather high earthquake resistance of largr-panel and frame building of precast reinforced concrete. In the areas with similar soil conditions the buildings with bearing brick and stone walls and buildings with brick external walls having frame made of precast reinforced concrete have suffered most of all. It was determined that the pliability of butt joints had a considerable influence on building rigidity particularly at the stage prior to distruction.While strong earthquake of expected intensity a reciprocal shift of panels occured in large-panel buildings which absorbed the major amount of vibration energy and decreased seismic forces in the zone of rsonance modes without making any damage in bearing precast members.

4. For the last few years the prestressed reinforced concrete structures are being used in earthquake engineering Their behaviour during earthquake is rather reliable.Experiments carried out in different countries had also proved satisfactory behaviour of prstressed structures under seismic loads. They showed good strength and absorbtion ability of vibration energy.

The influence of prestressing on dynamic strength and rigidity as well as on damping of vibrations in reinforced concrete members was revealed as a result of investigation of a great number of reinforced concrete prestressed and coventional beams reinforced with different grade of steel and also columns and models of frame structures. In members having secure grip between concrete and steel prestressing does not decrease the strength of reinforced concrete structures under instant dynamic loads. The influence of prestressing on dynamic rigidity of reinforced concrete members depends on initial prestressed-deformed state of sections, the magnitudeof prestressing,character and duration of load effect etc. At the beginning of loading till the appearance of cracks in concrete,the dynamic rigidity of prestressed member differs very little from the rigidity of elastic member. In the stage which is close to distruction when the reinforcement aquires non-elastic deformations and prestressing is nearly lost its influence on dynamic rigidity of reinforced concrete member will be minimum,but the magnitude of dynamic rigidity of prestressed members upto destruction remains to be greater than that of conventional reinforced concrete members. in the stage close to distruction the vibration of separately tested columns is increased by 2.0-2.5 times which testifies to the decrease of averaged rigidity by 4-6 times,but the vibration periods of frames are increased by 6 times related to the formation of plastic joints.

It has been experimentally proved that prestressed reinforced concrete beams with class A-IV reinforcement rod (normative resistance - 6000 kg/sq cm)and A-III B (normative resistance - 5500 kg/ sq cm) show an increase in plastic deformations under instant dynamic loads better than under static ones.

The damping of vibrations of conventional and prestressed reiforced concrete members (beams,colums,frames) under loads which make up 70% of the distruction is practically constant and the magnitude of energy dissipation ratio which is taken as double value of logarithmic decrement is in the range of 0.3-0.5 for beams, 0.4-0.8 for columns and o.9-1.6 for frames. The absorption of energy is increased with dynamic load which is close to the limits, then the energy dissipation ratio reaches the following values: 1.2-1.6 for beams, 3-4 for columns and 2.1-3.5 for frames.

Thus,shortly outlined dynamic features of prestressed reinforced concrete structures and some data of their behaviour during strong eartgquakes that occured for the last few years characterize rather high earthquake resistance of prestressed reinforced concrete structures. High crack resistance of prestressed structures and their facilities to return to the primary state afterrelease of load due to closure of cracksand release of flexures was a very propicious factor. While overloading caused by strong earthquakes in the most stressed areas of flexible members,cracks and non-elstic deformations will be developped. In this case the condition of work of prestressed structures becomes very close to normal one which is characteristic of structures without prestressing. Some dfinite requirements for securing facilities of development of non-elastic defofmations in flexible prestressed structures are therefore included into our Building Code.

BIBLIOGRAPHY

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