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3rd Session: EFFECTS OF THE RECENT EARTHQUAKES IN ITALY AND OTHER COUNTRIES

DISCUSSION

Paper 3/1 V. MIHAILOV - YUGOSLAVIA

"Friuli Earthquake 1976. Strong Motion Accelerograph Records"

CLOUGH

I just wanted to ask you if the distance magnitude intensity relationship which have been found in California differed considerably from the kind of information that you got from your seismograph stations in Yugoslavia.

MIHAILOV

Yes, we tried to find some correlation between these acceleration curves and the results in Yugoslavia during the earthquake. But we can't find any correlation because this 52% of g acceleration is extremely high.

PETROVSKI

Once more I would like to point out that the strong motion records are primarily important for earthquake engineering development. It seems from the records of the Friuli earthquake that it had significant differences for the same source mechanics; probably, the influence of topography and local soil conditions is significant and of predominant character. We need to make additional studies of local conditions, and to have correlation of all the parameters involved.

Paper 3/2 E. HEIMGARTNER - SWITZERLAND

"Structural Behaviour of the Damaged Buildings during the Friuli Earthquake Between May 6 and September 15, 1976"

FLESCH

Have you also done investigations on the seismic behaviour of steel structures?

HEIMGARTNER

Yes, we have done some investigations on steel constructions, but there are very few such constructions in the Friuli region. I remember one factory which has been under construction at that time, and there was no damage at all.

GRANDORI

I would add a few comments about the work which is now being carried out by the Ministry of Public Works and by the regional government in order to improve the civil code. In that zone the code which was in force before the last earthquake was certainly not adequate for the seismicity of the zone. But we had no elements, just after the earthquake, for an accurate distribution of seismic arrangements in the zone. So the Ministry decided to adopt a preliminary seismic code for the urgent works of starting reconstruction and to carry out in parallel a deep study on the subject. Within one or two months a new, detailed seismic map of the area will be used to have satisfactory seismic protection, taking into account the seismicity of the variuos zones. This new seismic map will be the basis of massive reconstruction.

BRUSCHI

I wish to point out that the two curves shown in fig. 21 are not really comparable, because if we perform a dynamic analysis with a ground acceleration spectrum like the one indicated in that figure, we should also take into account the ductility of structure, which reduces considerably the forces and stresses in the structure. For instance, the new Project of Argentine Earthquake Regulations, prepared by IDIA, states a formula for acceleration spectrum which leads to a curve similar to that indicated in fig. 21, but also states that forces obtained by the dynamic analysis shall be divided by the ductility factor, which may be as high as 6 or 7.

On the other hand, static analysis using a seismic coefficient C = 7 or 10 or 15 per cent should also lead to an adequate design, as I indicated in the short communication on Caucete Church.

HEIMGARTNER

Experience shows, that damages or even collapse may occur on buildings which were designed according to normal building code requirements (e. g. with 2 to 5% horizontal forces). On the other hand, if an engineer has to assure that a building remains functionable after an earthquake (e. g. hospitals, nuclear power plants), he can't take into account too high ductility and he should design the structure according to the real earthquake forces. The upper curve shown in fig. 21 doesn't consider any ductility of the structure,

while the lower curve shows the response of a structure with a very high ductility (and therefore at least moderate damages).

Paper 3/3 M. VELKOV - YUGOSLAVIA

"Behaviour of Large Panel Building during the Romanian Earthquake of March 4, 1977"

LANE

Prof. Ambraseys has said in one of its papers that the predominant periods of the Rumanian earthquake were very much higher than usual, and he commented that those buildings with corresponding natural frequencies were the ones badly damaged. Is that correct?

VELKOV

Yes, you are right. During my talk I explained that the predominant period in Bucharest was 1,4 - 1,5 sec. However, it was obvious from the Ploesti slides that rigid structure suffered also heavy damage which could be explained by different soil conditions. Therefore, the frequency content of the seismic effect is certainly different from the one which is shown on the Bucharest record. Thus, in Ploesti, structures constructed of precast elements having the same dynamic characteristics exhibited excellent behaviour while masonry structures on the same location suffered severe damage.

CANSADO CARVALHO

I visited Romania about a year ago, and I would like to give my impressions. The behaviour of panel buildings in Bucharest was very good but the predominant long period of the earthquake must not be forgotten. I visited also Iasi, which is approximately at the same distance from the epicenter but in the other direction, in northern Romania. I think that there the long period effects were not present. Actually although having not been obtained any accelerogram in that zone, the pattern of damage was completely different from Bucharest. The one and two storey masonry buildings were damaged and some panel buildings in that city clearly showed cracks in horizontal and vertical joints. So the point that I would like to emphasize is that the good behaviour of panel buildings in Bucharest during the past year earthquake should be carefully analysed considering the possibility of the occurrence of different frequency content earthquakes.

Paper 3/7 R. PRISCU, D. STEMATIU, L. ILIE - ROMANIA

"Considerations Concerning Earthquake Response Analysis of Rockfill Dams"

CLOUGH

The paper describes reduction of seismic response in large dams due to "non-synchronous" input. However, an addictional effect of such input is not considered: that is the direct straining of the dam due to differential movements of the foundation layer. Our studies, reported at 4th W.C.E.E. in Chile, show that these direct strains can lead to a total increase of response due to non-synchronous input. Please comment on this aspect of the total response analysis.

PRISCU

Referring to professor Clough's intervention a mention should be made that all the comments on the response decrease are concerning the accelerations only, which are to be used for the pseudostatic stability analysis. However, the additional effect due to the direct straining of the dam caused by the differential movement of the foundation layer leads to a quite significant increase of the total response, as far as displacements and stresses are concerned. The authors did not make an analysis of the displacement and stress effect of the non-synchronous character of the earthquake input mechanism. If the dam stability analysis is to be made based upon the effective stresses induced by the earthquake, the second above mentioned effect has to be included.

Paper 3/10 U.W. STÜSSI - SWITZERLAND

"The Modelling of Special Water Filled Structures under Seismic Loads"

CLOUGH

I have two questions. Is there a roof on this tank; and do you know how full the tank was?

STÜSSI

The roof was on the top, and the gap between water and roof was about 35 cm. The height of water surface in the cylindrical part of the container was about 45 cm.

CLOUGH

Do you believe there was impact of the liquid on the roof?

"
STUSSI

No, I don't believe that. The roof was destroyed in falling first on an adjacent building and then on ground.

BRUSCHI

In the beginning you mentioned an opening in the shaft. How did you take this into account?

"
STUSSI

We made a case study and took it into account by calculating the lateral force deflection curve, and you can see that the lateral force will be reduced only by 5%.

PINFOLD

In this type of structure, where the natural frequency of the water can be anywhere near that of the structure as a whole or the exciting earthquake, it would be wise to insert walls to compartmentalize the tank, so that as a whole it does not move around the entire area.

"
STUSSI

One can show that sloshing in this type of container does affect the whole structure response very much. So it may be wise to insert separating walls.

PINFOLD

It will depend on the proportions. I think every case may be different. Secondly, from the photograph it looks to me that the failure could be possibly by shear failure and not a bending failure.

"
STUSSI

It was perhaps a bending failure because the shear force is not very high.

WILLYE

I would like to make a comment on observations of water tanks of this nature. One of the more interesting observations I made of the Friuli earthquake was of a steel water tank at the Sidero steel plant by Maiano. This was a much larger tank, supported by a substantial big steel frame with a saddle supporting the steel tank inside it. After the earthquake of May 6th, the tank had rotated about 10° inside the saddle, apparently due to torsion of the water. When you think about this, it is logical. If you take a glass of water, and if you move it just in one direction, as we conventionally analyze structures or tanks, the water will slosh just back and forth. But if you give the glass of water a random three-dimensional motion, as the water will actually experience in an earthquake, you will eventually get the water to swirl in the glass, just like I believe the water will eventually in the tank. If the tank has stiffeners or battens, this swirl of water will exert considerable torsion forces on the tank. Friction will also create considerable torsional tendencies. This was very interesting for this steel tank, and I know when I saw the concrete tank discussed by Mr. Stüssi I wondered if perhaps there was a little torsion in that tank too.

STÜSSI

And the structure was absolutely symmetric?

WYLLIE

Yes, the steel tank was absolutely symmetric.

STRATTA

Before we finish with the questions, I would like to summarize the following, because it appears some confusion has arisen and we must remember that:

1) Peak acceleration is not a function of magnitude.
2) Damage is not a function of peak acceleration or magnitude.
3) Damage is not necessarily a function of distance from epicenter.
4) Static "force coefficients" for commercial and industrial structures need not exceed at most 0.15 g.
5) Peak acceleration should not be confused with "force coefficient".
6) Soil conditions and relationship to damage should be noted.

PETROVSKI

In general one would agree that peak acceleration is not controlling the

entire response of the structural system. But it has important influence as far as the magnitude peak acceleration relationship is concerned. We do not know much about it, excepting California. We need more experimental evidence.

STRATTA

No, I think you have got quite a bit of evidence in the earthquake of 1970 and 1974 in Peru. Both earthquakes had a similar magnitude, about 7.6, were similarly located off-shore, and yet one created an earthquake which killed 80,000 people and the other one created an earthquake which killed 125. And yet they were of similar magnitude, affecting similar types of structures, and yet one was very destructive and the other was not; and going into the seismograms we had quite a conversation with Dr. Bolt of the University of California. He was able to show that peak accelerations are not a function of the magnitude.

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