WHY "REGULATIONS FOR STRUCTURES IN EARTHQUAKE ZONES" IN GERMANY?

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Compared to the Mediterranean Countries of Europe or some other parts of our planet, Germany is not a typical earthquake land. One would assume, therefore, that in designing structures in Germany, the effect of earthquake on the structure can be ignored. Such judgment, however, is somewhat too optimistic. Hundreds of years of experience has shown that from time to time, earthquakes occur in certain parts of Germany, especially in Southwestern Germany and the Rhine land and cause applicable damages to houses and industrial structures. The minimum intensity of earthquake which was observed in Germany during the past centuries and which can be anticipated in the future can be expressed as Grade 8 on the 12th Grade Mercalli-Cancani-Sieberg Scale. During an earthquake of this intensity damages to buildings occur normally within a radius of 30 to 40 km. From the source of earthquake, the damage to structures resulting from such an earthquake amounted to 3,000,000 to 5,000,000 Marks in several cases.

Such earthquakes are fortunately rare in Germany. In certain quake zones, centuries may pass between damaging quakes. It is this great time interval that makes people forget as in cases of unusual atmospheric phenomena, the dangers of earthquake in certain areas. Frequently during one generation and certainly in the second generation, most has been forgotten. Therefore, it is at this point very appropriate and even necessary to mention the experience and knowledge accumulated during a long period of time. Judging by the damages, one has the impression that some of them would not have occurred or that their magnitude would have been lessened if possible earthquake had been considered during the design of these buildings or if the use of unsuitable soils had been avoided.

The design guides for structures in earthquake areas serve the purpose of utilizing the experiences about quakes and applying them in the future in order to avoid or minimize the extent of damages. It is frequently possible to achieve this by simple means without great additional construction costs. This factor is worth consideration in Germany, which is not a typically earthquake country. The design guides should apply to large buildings like factories, schools, churches, etc., where many human lives are involved, and to structures like bridges, high smoke stacks, water towers, etc. In all of these cases, special attention should be given to the soil which greatly influences the effective quake force and thus the resulting damage. The effective force in cases of unsuitable soils (saturated clayey, sandy, gravelly

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or marshy soil with low bearing capacity or a stratum which has the tendency to slide) is frequently by one or two degrees greater than in cases of good soil (sandstone, limestone, or solid marble). This underground influence is quite apparent during earthquake. During the quake in Oberschwaben, which occurred on June 27, 1935, for example, all buildings on one side of a particular road which were built on marshy soil foundation were more or less heavily damaged, whereas those on the opposite sides, built on firm soil, have practically escaped damage. Similar phenomena has been observed along a road in Ebingen during a quake on May 28, 1943. Many similar examples can be named.

Because the earthquake danger differs appreciably in different parts of Germany, it was necessary to assign zones in which there is an effective earthquake danger. Two zones are distinguished. Zone 1 includes areas in which quake intensities of Grade 8, and Zone 2 where quakes of Grade 7 can be anticipated. The subdivision into zones is based on the observations of intensities of past quakes and on the recognized fact that in certain provinces, all heavily disturbed area earthquakes can be expected in the future. The period of observation from which records of damages are on hand is, of course, very brief compared to the time during which the geological forces in the earth's crust act.

Pictures 1 through 8, represent a small selection of typical damages in German earthquake zones. Damages are far from being harmless and earthquake presents a definite danger. Slender structures like church steeples and smoke stacks are subjected to high shearing stresses in their upper portions. These stresses must be taken in account during the analysis of such structures. The gable walls of the church steeples in Kappel and Kanzach should have been tied to provide for greater stability. Superstructures, like small towers which serve only decorative purposes, should be avoided in earthquake zones.

Due to the fall of masses from great heights onto lower buildings, secondary damages result whose magnitude frequently exceeds that of the original earthquake damage (churches in Kappel and Kanzach, factory building in Tailfingen, Figures 1 to 4). The gable walls of ordinary buildings are also endangered if they are not adequately anchored to the roof structure (house with barn in Onstmettingen, house in Billig, Figures 5 and 6). Portions of buildings which are built onto a larger building are subjected to greater stresses for their own time of oscillation greatly deviates from that of the main building mass causing intensified counter oscillations (corridor of the Bismark School in Tailfingen, Figure 7). In regions where earthquakes can be anticipated, buildings should be made simple and comprising one single unit. Light arch structures in churches which usually cannot withstand additional stresses should not be built in quake zones (Figure 8 - church in Overgartzen).

Aside from the fundamental requirements of the soil and simple unified structures, it is difficult to establish general, all inclusive guides for design. It is, therefore, necessary to consult the experienced construction specialist and the seismological services of a particular area in each individual case.

Figure 5
The end wall of this barn was completely demolished. The wall was not anchored. Quake of May 28, 1943.

Figure 6
During the quake of March 14, 1951, the end wall of this house in Billig, was so badly damaged that it had to be completely removed.

Figure 7
This outer corridor wall of the Bismark School in Tailfingen badly cracked during the quake on May 28, 1943.

Figure 8
Large portions of the inner arch of this church building in Overgartzen fell out during the quake of March 14, 1951. In addition, the seats of the church were badly damaged and the church remained closed for a long time.

Figure 1
During an earthquake on June 27, 1935, in Kappel Bei Buchau on Lake Feder, both end walls of a gabled-roofed church steeple were thrown out because they were not anchored. One of the walls fell onto the ground without causing any further damage, while the other fell onto the roof of the church, broke through it and through the ceiling and, thus, caused an appreciable secondary damage.

Figure 2
The interior of the church in Kappel by Bei Buchau Am Federsee after the earthquake on June 27, 1935.

Figure 3
Both gable walls of a peaked roof on a church steeple in Kanzach fell out much like in the Kappel case. Quake of June 27, 1935.

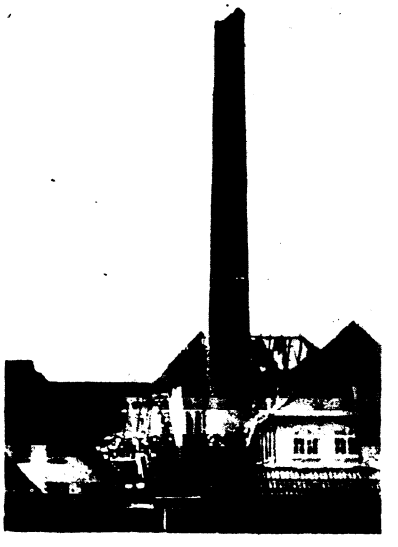

Figure 4
Broken off top of factory smoke stack in Tailfingen during the quake of May 28, 1943. Appreciable secondary damage was caused to the factory building itself.