

CONSTRUCTION IN EARTHQUAKE COUNTRIES.

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The following is a translation of a report of the Royal Commissioner appointed by Royal Decree April 13th, 1885, to provide for the reconstruction of buildings destroyed by earthquakes in the provinces of Granada and Malaga.*

The following five types of buildings have been adopted by the "Royal Spanish Building Committee" for the construction of new houses in the provinces of Granada and Malaga, out of the proceeds of the international subscription in favour of the sufferers of those districts, whose properties were destroyed by the earthquakes of 25th December, 1884.

These types of construction vary according to the magnitude of the house and the respective cost price, and are, as far as the Spanish technical experts say, quite earthquake proof.

It is to be noted that the following types represent small dwelling houses.

FIRST TYPE.

This is a house of two stories of at least 5 mètres frontage and 8·80m. in length, divided into two wings, whose free width on the lower story is 3·50m., and on the principal storey 3·60m., forming two apartments in each floor. The room at the entrance downstairs is the kitchen, with hearth and chimney in the country style, which according to the custom of these

* Memoria del Comisario Regio, nombrado por Real Decreto de 13 de Abril de 1885 para la Reedificacion de los pueblos destruidos por los terremotos en las provincias de Granada y Málaga. Madrid, 1888.

inhabitants serves besides as an eating-room, sitting-room, and even as a dormitory. For this last purpose the other three rooms may be used, although on account of their size they may be also reserved as repositories for fruit, corn, and other things. The space under the staircase is closed by a thin partition wall with door, and forms a small cabin to be used as a pantry or for other purposes. The lower apartments receive the light from the doors of the street or of the court-yard. These doors are 2.50 mètres in height by 1.10m. in width, and possess on the upper part of their frame a glass window. On the upper story, each apartment has a window, 1.30m. \times 1.90m., with glasses and cloister wings. The plan of the house covers 116 square mètres, while each room has a surface of 15.50m. and a volume of 50 cubic mètres downstairs and 45 cubic mètres upstairs, these figures corresponding to the different elevations of the respective roofs, that is to say 3.25m. and 2.85m.

The following details complete the description of this class of house :—

The foundations are of ordinary masonry, having a thickness of 0.70m. and a depth necessary to reach in all cases firm ground. The external walls as well as the transverse ones are of the same material, of a thickness of 0.60m. in their lower part and 0.50 in their upper part. The external walls are bordered at their respective terminations by a brick band, and strengthened at the angles by brick buttresses, whose junction with the masonry walls is effected by means of indented projections, into which are built the massive parts of the wall. The lintels of doors and windows are formed of three timber-pieces joined together by bolts inserted into them; and the lining of these spaces are also of bricks. These, the buttresses and the horizontal bands, constitute, by their arrangement, their colour and their projection over the outside wall lining, the decorative elements of the front and back *façades*. The floor of the lower storey is, with the exception of a stone passage to the court-yard, of common paving-

bricks; it is higher than the level of the road and generally rests on a dry filling of stones, half a mètre thick. The upper story is floored with rabbitted boards, and its frame-work consists of joists of $0.75\text{m} \times 0.16\text{m}$., their distance from each other being 0.30m . These joists are attached to their girders resting on the walls, and are bolted and immured in the same walls. These girders together with the beams, which at the same height support the partition walls, form a general framing, whose angles are strengthened by iron ties. An analogous frame receives, on the top of the second floor, the truss of the roof; which consists of rafters and tie-beams of $0.75\text{m} \times 0.11\text{m}$. at a distance of 0.50m . from each other. The covering of the roof, which forms two slopes, in some houses overhangs the external walls, thus forming large eaves; in other houses it only covers the brick cornice into which the band or top of the wall is then turned. As the tie-beams of the truss support the flat ceiling of the upper storey, the ventilation of the truss in houses forming a street angle (they are almost all in such condition) has been arranged by means of a round garret-window in the slopes of the roof, and in other houses by angular openings in the roof lined with clay. The internal lining is made of plaster and the external of fine mortar composed of lime and sand. The timber used in this and in the next type of houses, with the exception of some pieces of well-cured native pine, are of North-European red pine, alder-wood being absolutely excluded on account of its weakness and liability to decay.

Houses of such type and of the above mentioned size have been built in Alhama, Arenas del Rey, Albuñuelas, and Güevéjar; however, in four houses constructed in the first named place the length of the front has been extended to 8.60m ., this giving to the houses a surface of 76 square mètres, which allow the construction of four rooms in each story, or eight in each house.

SECOND TYPE.

It differs from the preceding type in having only one wing,

whose width, including the thickness of the frontage walls, is 4.70m., the width of the façade, which in the first buildings constructed is of 5 mètres, not allowing more than one apartment for each story. These houses, however, of only two rooms were of limited use, as they could only serve for very small families. On this account only a small number of these have been built, giving to the others which belonged to the same type a greater length of frontage, say of from 6 to 11 and 13 mètres. These were the largest houses. This greater length has caused the building of houses of three apartments, one downstairs and two upstairs, when the façade had a length of from 6 to 7 mètres; of four rooms, two in the lower storey and two in the upper storey when it had 7 to 8 mètres; and of six apartments, three in each floor, in houses of a frontage of from 11 to 13 mètres. The surface occupied by these houses is between 23.50 square mètres for the smallest, and 62 square mètres for the largest buildings.

This type is to be found in all the hamlets and villages which have been built by the Royal Committee, and has been the most commonly used, as the number of houses of this system, including all the different varieties, is equal to that of all the others taken together. This special preference is not difficult to explain, the kind of construction and the class of materials rendering these houses superior to the buildings of the third, fourth, and fifth types; on the other side offering over those of the first type the advantage that by an equal surface of ground they had a larger court-yard, this being a convenience much appreciated by the working class. Such houses are also better adapted for enlargement, as it is quite sufficient to add a wing to them in order to double their capacity without depriving them of a sufficiently large court-yard. This is not the case in houses of the first type, which, by such operations, do not increase more than one half of their capacity, remaining deprived or almost deprived of that convenience. Another favourable condition

of the second type is that it is better adapted than the first type to the different classes of indemnity. (Here the word indemnity refers to the part of the subscription allotted to single sufferers.)

THIRD TYPE.

This is the first type of economical houses, and differs from the preceding only in the suppression of the brick construction of the external walls and in the stone filling of the pavement of the lower story; in all other details it is equal to the house of the second type: frontage of 7·20m., length with a kitchen (to serve also as dormitory) downstairs and two dormitories in the upper story. Only a few houses of this kind have been built in the new village of Güevéjar.

The three houses which have been described, present enough common characteristics, giving them such similarity as to have them considered, generally speaking, as several varieties of the same type. This is, however, not the case with the two other types, which when compared to each other or to the preceding types, offer radical differences, and are excepting in their execution, equally perfect, as will be seen from the following descriptions.

FOURTH TYPE.

It corresponds to a house having a plan of 4 mètres frontage and 10 mètres depth, consequently occupying a surface of 40 square mètres. The external walls are of common masonry; their thickness 0·50m. in the foundations, and 0·45m. above the same; their height 3·20m.; they are crowned with a thin brick cornice. The partition walls are either walls of 0·15m. thickness or masonry construction with *brown mixture*, 0·40m. thick. Each frontage has two openings: a door 2·40m. × 1·10m. and a window 1·50m. × 0·75m., the latter having window glasses in cloister style, protected by cross-bars; and the former by two strong shutters. The covering has two slopes, and its frame, which differs in its arrangement from that usually adopted, is as follows: the timbers, which are pine

poles of 0·12m. diameter, and in this case take the place of the rafters of a simple truss, lean with their ends against the inclined girders, which rest on the corner sides of the partition walls, so as to be parallel to the top-beam. The object of such arrangement is to avoid, for the covering, the necessity of trusses of 10 mètres opening, which would render the construction expensive. The space circumscribed between the four walls of the house contains a large kitchen of 5·50m. \times 3·60m.; another room of 3·50m. \times 2·45m., which may be used as a dormitory, and is separated from the former by means of a simple partition and a small corridor 1·15m. wide, which leads to this dormitory and to the court-yard; the pavements of the kitchen and corridor are of stone, while the other dependencies have a brick-floor. There exists besides an upper room, to which a staircase leads, and which may be used as well for a dormitory as a repository for fruit and effects. The storey formed by this room has a timber floor, and its framework supports the flat ceiling of the lower dormitory. This type is to be found in the same places as the second type, and is, after this, the most common, it having been chosen on account of its lower price, in order to indemnify a numerous class of owners with cheap small houses.

FIFTH TYPE.

It has only one storey, and its plan has a frontage width of 9 to 10 mètres by 8 to 9 mètres of length. The house is divided into two parts by means of a transversal wall, which in some houses consists of masonry, while in others of thin brick partitions. The external walls are of ordinary masonry and the others of masonry with brown mixture; their thickness is 0·60m. at the foundation and 0·50m. above it, their height up to the roof 3·20m. It contains a kitchen with a door and a window, another room with an opening on the same side, and two others with openings over the court-yard, and a small corridor which leads to this. The free surface of these houses being of 56 to 72 square mètres, their dependencies are large and their surface is not under 30·20m.

The floor is paved with bricks, excepting the kitchen and the corridor, which have stone pavements, and the ceiling is flat. The roof in most of the houses has two slopes, and its truss rests on the principal walls in a similar manner to that described in type fourth. In these, and in the other more economical houses, the timber used is pine from Northern Europe and of native growth.
