ABSTRACT

OF THE "REPORT ON A GENERAL SYSTEM OF CONSTRUCTION FOR PUBLIC AND PRIVATE BUILDINGS TO BE ADOPTED IN THE PHILIPPINE ISLANDS," DRAWN UP BY THE MILITARY COMMITTEE OF MANILA, 1863.

(Informe sobre el sistema general de construcciones de los edificios publicos y particulares en Estas Islas, 1863. An MSS. received from General Cerrero, Manila.)

The Governor-General of the Philippine Islands invited a Military Committee, consisting of officers of the Royal Spanish Engineering Corps, to give its opinion on the following five questions:—

1. On the study of the destructive effects caused by the earthquake on the 3rd June, 1863. On the adoption of a general system of building which should harmonize with the conditions of the country.

2. Whether the hospitals, convents, colleges, jails, and "beaterios" (ladies' religious communities), which have been destroyed during the earthquake, should be rebuilt in other situations enjoying better sanitary conditions.

3. On a new general system to be adopted for tracing roads of inhabitated places.

4. Whether the walled city must be considered as a citadel and the military area of Manila reduced.

5. On what site the new provisional buildings, which have to serve for Government Offices, should be built.

1ST QUESTION.—On the study of the destructive effects caused by the earthquake on 3rd June, 1863, and on the adoption of a general system of building which must harmonize with the conditions of the country.

The Military Committee points out that the effects which have been caused on buildings by the earthquake of 3rd June have been different and contradictory. In some cases buildings of two stories have resisted better than neighbouring houses of only one storey, while in other cases the contrary has been observed. Some brick and stone buildings have stood well, while wooden constructions have been destroyed, and vice versa. Even some badly constructed houses have better resisted the shakings than others built with the greatest care. In consideration of these facts, nothing reliable could be deduced, were it not for certain effects of a general character which have been observed. These have led to the belief that the contradictions above mentioned find an explanation in the situation of the different buildings with respect to the undulations or general course of the phenomena producing the undulations.

For the most part it has been observed in buildings which have greatly suffered, that, while in two-storied houses the damage finished at the junction of the lower with the upper storey, in one-storied buildings it extended over the whole structure.

Most of the cracks originated from the great violence of the earthquake, having disconnected the heavy roofs of buildings, as well as on account of the bad construction of the so-called "caidas" (verandah roofs). Finally it has been noticed that masonry supports have generally suffered much more than those of timber, and this especially on account of the bad construction of the former.

The Committee believe therefore that the following two principles ought to be observed:—

(1.) To introduce as light roofing as possible.

(2.) To connect and join together all parts of the buildings, employing in the construction only one kind of material, and in this way avoiding difference of elasticity. To carry out the first principle, zinc or galvanized iron roofs would be the most satisfactory method of covering buildings; however, in consideration of the meteorological conditions of the country and in order not to depend upon such materials, which are of foreign manufacture, improved tiles of home manufacture are proposed. The tiles at present employed being bad, the Committee offers to exhibit samples which are better. As to the second principle, the Committee is of opinion that masonry supports, in consequence of their rigidity, difficulty of joining, and of the difference between their elasticity and that of the timber of the roofing, are not to be recommended. Masonry supports have greatly suffered during the last earthquake. Iron supports and trusses, although preferable to those of masonry, might not satisfactorily resist the different seismic motions. Timber supports and trusses are therefore to be preferred. The following rules of construction ought to be observed:—

Public buildings must not have more than one or, exceptionally, two stories. Gaols, hospitals, schools, and all other buildings where a great number of people assemble, must not have more than one storey, and their maximum height over the soil must not exceed 21 feet. The spans of these buildings cannot be more than 27 feet in width, and should it be necessary to have them wider, they must be provided with a metallic covering. Should, however, the covering be of tiles, trusses with intermediate supports must be used. These double spans, unless it is absolutely unavoidable, cannot have more than 42 feet width, and in this case they must be covered with zinc or galvanized iron.

Coverings of tiles must be as light as possible. Tiles must be modified in form and size and well supported at the edge of the roof. Supports of roofs must be of timber and strongly joined in perpendicular and parallel directions, as well as at

their base at the level of the floor, and at the tie-beams of the roof-trusses. Over the tie-beams a wooden floor must be put, in order to protect the lower part of the building in case of a catastrophy. Outside the supports and at a distance of 6 to 8 inches from them, wooden walls will be constructed, which must have a thickness of from 2 to 3 feet and be strongly joined with the transversal walls of the building. Over all the walls strong beams well joined and strengthened at the corners must be placed.

Churches can have posts or supports, trusses, framework and covering of metal, provided that they have the necssary lightning conductors. However, wooden constructions with light metal roofs joined as has been already described, are to be preferred. The height of churches must not exceed 30 feet. church-towers must be constructed only a little higher than the main building, be very light, and have supports of timber.

Government Offices can have two stories, provided that they be constructed like private buildings.

Private Buildings must have posts, walls, frame-work, and trusses of timber. They can have two stories and also a high basement. The width of the galleries cannot exceed 12 feet and that of the dwelling-rooms must not be more than 25 feet. Galleries, however, can have the same width as the dwelling, provided that they be well supported and that the roof of the main building covers the whole block (even galleries or verandahs); walls must be of timber and built outside of posts or supports, at the same distance apart and under the same conditions as we have explained for public buildings. Supports must be joined and strengthened as in public buildings.

The partitions of the upper storey must be light and made of timber, and in the junctions of the framework the triangular instead of the rectangular system must be adopted, as it strengthens the posts and supports the doors and windows.

Projecting verandahs or balconies are not to be recom-

mended, but as they are very useful in Manila, they can be constructed between the edge of the wooden post and the external lining of the walls of the first storey. Stone or brick lintels must be strengthened by timber supports or beams, and when arches are used they must be small, flat, and well executed.

2ND QUESTION.—Whether the hospitals, convents, colleges, gaols, and "beaterios" (ladies' religious communities), which have been destroyed during the earthquake, should be rebuilt in other places enjoying better sanitary conditions.

The Military Committee is of the opinion that the convents, "beaterios," colleges, gaols, and hospitals, which have been destroyed by the last earthquake, ought to be rebuilt outside the city, not only from a sanitary point of view, but also because such a situation seems more suitable to their objects as they will then not be surrounded by private houses. Should this be done, then the Government and the community will be able to dispose of many vacant building places in the city.

3RD QUESTION.—On a new general system to be adopted for tracing roads of inhabitated places.

The Committee is of opinion that the streets of the walled city (Intramuros) being generally narrow, they should be widened. The principal roads ought to be at least 36 feet wide, and the others 30 feet. Street corners and cross-ways must also be widened and some squares formed.

The suburbs (Estramuros) must have roads of from 48 to 60 feet wide.

4TH QUESTION.—Whether the walled city must be considered as a citadel and the military area of Manila reduced.

The Committee will not venture to touch upon such a grave question, which military officers are not allowed to publicly discuss, but it is of opinion that special circumstances do not permit any alteration of the tactical area of Manila.

5TH QUESTION.—On what site the new provisional buildings, which have to serve for Government offices, must be built.

(This being of no importance for Japan, the reply is omitted.—*J.M.*)

(Signed) MANUEL DE HEREDIA.

EARTHQUAKES, THEIR EFFECTS ON BUILDINGS AND PRACTICAL MEANS TO AVOID THEM AS FAR AS POSSIBLE, BY LIEUTENANT-COLONEL DON MANUEL CORTÉS Y AGULLÓ (1873 AND 1880).

(Los Terremotos sus efectos en las edificaciones y medios practicos para evitarlos en lo posible, Manila, 1881.)

(AN ABSTRACT.)

Lieutenant-Colonel Cortés, after having scientifically treated seismic phenomena, their history, and the probable causes of the same, describes the various effects produced by earthquake motion on buildings.

He shows that arches, vaults, and columns of masonry are dangerous in Manila, where earthquakes are so destructive. Besides the numerous errors in the details of construction, which have been already enumerated in the Military Report, as well as in that of the Civil Engineers and Architects, excessive employment of masonry walls crowned with large cornices and adorned with heavy projecting corbels, and a profusion of arches and vaults, have greatly contributed, during the last earthquake to the destruction of many buildings. Several churches, palaces, and public buildings, and especially those masonry constructions which suffered during the earthquakes of 1824, 1828, 1852, 1853, and other less severe commotions, have been completely destroyed in consequence of the last seismic phenomenon.

Lieutenant-Colonel Cortés starting, as he says, from the unfavourable supposition that earthquakes will in future be frequent and of great intensity, considers the soil of the

Philippines, upon which buildings have to be erected, as a semi-fluid surface, and concludes by declaring that there exists therefore sufficient analogy between constructions on land and ship-building. In both cases we have masses resting upon a moving medium of little molecular consistency and which transmits to them every motton to which it is itself subject. If ships can resist the motion, which the sea communicates to them in every direction, it is because they are built of light materials possessing sufficient resistance, because in joining these materials every precaution is taken that they be put together in such a manner as to form a single compact body. Those parts of a ship which do not possess the same resistance as the bulk, are strengthened by numerous auxiliary means, in order that they may acquire the strength which is required. Ship masts present great stability and resistance, not only on account of their shrouds, which join them with the ship, but chiefly because of their rigging, which fastens them to the main body of the vessel. Should their only purpose be that of transmitting to the ship the motion they receive from the wind, the shrouds would not require to be so deep at the lower extremity of masts, the ordinary rigging being sufficient to keep them vertical. Of course a mass made of hydraulic masonry would not resist so well as one of timber or iron ; and why? Because the latter with a lesser mass gives the same strength as the former ; because it is less liable to rupture, and it can be joined together by means of tie-beams, bolts, bridles etc. ; because it admits of construction which does not readily yield to a change of form, and because the whole receives at a given moment, less motion than if it were of masonry. If there therefore exists such an analogy, why should there not be the same means for the construction of buildings as are used for vessels?

It is just this we want: light buildings composed of continuous parts, that is to say at least those parts upon which

the resistance and stability of the construction depend must be continuous, and in those places where continuity cannot be obtained they must be so joined together as to form an indestructible whole especially avoiding changes of form at the angles.

This is, according to Lieut.-Colonel Cortés, the principle upon which buildings, in countries where earthquakes are frequent and of a certain intensity, must be constructed.

The author then criticizes the method of construction used in Manila. Having already spoken of masonry walls in general, he shows how piers and buttresses built on separate foundations are still more dangerous. As they support a part or the whole of the upper building, including the heavy roof, there is no doubt that a falling down of such structures is more to be feared than if the house had continuous walling.

In Manila, besides masonry and stone piers, timber posts (called "harigues") are also employed. These posts, which are from 50 to 60 centimètres thick, have a certain foundation, that is to say, their lower extremity is put into an excavation made in the ground, where their foot is surrounded by masonry or stone construction. They, together with the masonry walls, support the whole building. The difference of elasticity, existing between these two materials (timber and masonry), during earthquakes generally causes the posts to destroy their masonry supports and consequently the whole upper-building. "Harigues," being in direct contact with the soil, become usually rotten.

Over continuous walls, piers, or buttresses, sills are placed which render the walls weaker at their upper part. Upon the sills comes a support (usually tennoned in the sills) which receives the tie-beams. Supports and tie-beams are pinned by iron pegs.

Sills are very often fastened on the posts or "harigues" by means of a simple nail without any support, and over these

come the tie-beans. On the top of the posts, supports for the sills of the roof are put.

Posts joined together by perpendicular beams will not resist pressure, but those possessing supports at every angle offer a good resistance.

Flying Balconies or Verandahs running all around the building are generally constructed on the projecting floor-beams (figs. 1 and 8) and they are very dangerous as they support the roof. They hasten the falling down of the building. Fig. 9 gives an improved system of verandahs, which, however, is not safe enough. Lieutenant-Colonel Cortés proposes the construction of balconies supported by columns or posts (fig. 10), which besides being of greater security will be an ornament to buildings.

Joining of parallel walls is done in Manila by means of enormous tie-beams resting on supports and pinned together as we have seen. In some of the ancient buildings there are to be found even two series of tie-beams. As they are very heavy, they require strong walls to support them. Lieut.-Colonel Cortés is of opinion that it would be better to have lighter beams resting on the walls or transverse supports.

Roofing.—Roofs are in Manila, as we have already said, very heavy. They are built as can be seen from Fig. 11 as follows:—

Upon the walls, sills are put, which support projecting tie-beams covering the verandahs. Upon the tie-beams come two series of beams, one outside and the other inside the walls. On these beams rest the roof beams, the exterior ones called "sobrequilos," leaning with their upper extremities upon the inner roof-beams (quilos) at $\frac{2}{3}$ of their height. Light beams running paralled with the roof tie-beams support the "sobrequilos." They are tennoned and nailed at the junction of the exterior with the inner roof-beams. The "quilos" are tennoned and bolted together at their upper

extremities, which one projecting over their intersection. Between these projections the top-beam rests. Upon the external part of the roof-beams a series of longitudinal laths of "Molave," called "varaquilas" are fastened, and on these a perpendicular series of "Molave" laths ("varatejas") are nailed. Between the "varaquilas" and "varatejas" come the first tiles, which are covered with mortar, and upon the external laths we again have tiles.

The roofs, besides being very heavy, have the disadvantage of forming an angle where the rain-water gathers and therefore penetrates into the building. The little or no junction of the parts forming the trusses, the bad system of nailing together the roof beams at their extremities, their enormous size the total want of intermediate supports, the great quantity of mortar resting on the roof, and the deficient quality and form of the tiles, make these roofs very dangerous during earthquakes. Zinc and galvanized iron coverings are also heavy.

Lieut.-Colonel Cortés proposes coverings of good flat tiles, tied to the upper part of the truss with galvanized iron wire, and light timber beams well supported and joined together.

Details of the Proposed Construction.

Foundation.—Considering the softness of the muddy soil of the Philippine Islands and the frequent occurence of earthquakes, Lieut. Colonel Cortés is of opnion that the artificial consolidation of the ground is not to be relied upon and therefore believes that deep foundations are of no use whatever. Instead of these he proposes the construction of a timber platform, almost upon the surface of the soil or at a very little depth, giving to this basement a wide extension in order to impart great stability to the building. All its parts must be strongly connected together in every direction, and especially those which have to support the walling, must be joined with iron ties and bolts. The whole platform has to form a solid and compact mass, quite independent of the soil. However,

in order to avoid sliding, a limited number of fixed points connected with the soil must be established. These basements must be built upon a thin layer of hydraulic concrete, tarring the portions of the timber and iron, which are in contact with the concrete, and filling up with the same material the interstices of the platforms. Such a base will be thus quite independent of the soil and seismic commotions as well as cracks of the ground underneath will produce little or no effect on the building.

WALLS.—It has been already said, that the bad condition of masonry walls and especially of piers and buttresses built upon separate foundations, are caused by their heavy weight and by the facility with which they are ruptured both in a horizontal and in a vertical direction, and that in order to obtain stability they ought to be light and constructed of materials which can resist dislocation. We added also that this indispensable condition of stability ought to be established not only in each wall, but also in each pair of parallel supports.

The materials which present great molecular resistance are metals and timber. Iron is the most convenient because it is the most economical material. Cast-iron ought to be employed for supports and wrought-iron for the other parts of the framework. In the Philippines, however, the iron industry being small, this material must consequently be imported from abroad at a very high price. It is, therefore, not suitable for private buildings, but it would prove very useful and economical for the construction of large buildings, as for instance churches, palaces, and public establishments.

For private buildings timber ought to be used, it being the only suitable and cheap material. Timber has, however, its disadvantages, as for instance, that of short duration in consequence of its being subject to become worm-eaten and on account of fermentation, or rotting when exposed to atmospheric changes, in contact with mortar or owing to the want of necessary ventilation. There exist, however, means for preventing such deterioration. Timber should be cut during the dry

season, and one year before this a circular incision should be made in the trees, in order to prevent the sap from ascending. Afterwards an injection of insecticide fluid ought to be applied to the timber, which would replace the sap of the tree. Often a good result is obtained by exposing the timber after injection to the action of sea-water and then drying it. The best insecticide substance seems to be creosote. Injections of grease, covering the extremeties in contact with the soil with mortar or impermeable substances, and ventilation, are preservatives against dampness. The best method for preserving the extremities is to cover them with *esparto* or with Manila cord and then to cover this envelope with tar or other bituminous material.

Lieutenant-Colonel Cortés proposes to adopt for posts the system used in Spain, that is to say to have each of them supported by a base of lime-stone or granite. In these stones there is a cavity made for receiving the posts.

In Spain, front-walls are of stone or bricks and in all the other walls wooden frames are used. Posts of the wooden frame-work of the lower story rest upon stone bases. For other details see fig. 12. The spaces in the frame-work are filled with débris of other buildings, then tied with cords of *esparto* and finally covered with plaster. These walls can be very high (5, 6, and more stories); they last long and do not need repairs.

This method of building must, however, be altered in Manila. Buildings ought not to have more than two stories, as it is difficult to find timber of more than 8-10 mètres length. The joining of timber-pieces is not to be recommended in Manila. If, however, it is absolutely necessary, the joining of timber-pieces can be allowed, provided that this takes place at the height of the storey. Angle-posts must be of one piece. Stone bases must be surrounded by a construction of masonry. In the frame-work posts must be joined together in every direction. The wooden frame-work can be filled with bricks,

possibly with hollow-bricks. In internal walls it is desirable that posts project out of the brick work.

The principal inconvenience of this filling is that it does not possess any connection with the wood-work and that consequently the lining breaks. To avoid this it is proposed to have the walls built like fig. 13. The post must project over the bricks and between two of the posts, laths of "molave" or pieces of strong canvas may be fastened covering the bricks. These laths or pieces of canvas can be plastered. Instead of bricks concrete can be used, (see fig. 14). If in this case it is desired to have the plaster applied to the wooden parts of the wall, these must be covered with a trelis-work of tarred cords.

If it is absolutely required, a square-stone wall, quite independent of the wooden one, can be constructed (fig. 15), but this kind of construction ought to be avoided.

Fig. 16, 17, 18, 19 and 20 show the different ways in which the beams of the stories may be fastened to the posts.

TRANSVERSE WALLS.—If there are no openings see construction fig. 21, and if openings exist see fig. 22.

FLOOR-FRAME.—Fig. 23 gives the frame-work of a mezzanine or high ground story. According to it the pairs of floor-beams closing the posts are longer than the others, and at places where they meet the posts they are joined together as is seen in fig. 23, intermediary floor-beams may be joined as in the drawing. Distance between the floor-beams 50 cm. Should the building have another storey, the intermediary floor-beams must be joined as those closing the posts and supported in the angular direction as shown in fig. 20.

TRUSSES.—Drawings 24, 25, 26 and 27 represent the different systems adopted in Europe for tile roofing. The author recommends these systems, but with some variations. Light materials and simplicity. See fig. 28, 29 and 30. For metallic roofing Lieutenant-Colonel Cortés proposes the truss given in

fig. 31 (for details see fig. 32), 33 and 34 (for details of 34 see fig. 35).

The author of the pamphlet then treats of the effects of the climate of the Philippines on buildings, as well as those produced by dampness, rain, and lightning.