LESSONS DRAWN FROM THE MOST RECENT EARTHQUAKES IN ITALY

by

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Summary.

The effects of the earthquake of 21st August, 1962, with epicentre in Irpinia (on the borders with Sannio and Apulia - Italy), and of the earthquake of 28th August, 1962, which, with epicentre in the Peloponnese (Greece), was felt in Apulia show: an accentuation of earthquake damage due to the age of poor houses and the failure of the mortar to hold; that the intensity degree based solely on damage to poor constructions may be more than a degree out on the MM Scale; that experience regarding the seismic response of old, tumbledown villages does not help in the drawing up of building codes in territories subject to earthquakes.

I.- The Earthquakes of August 1962 and Their Effects in Campania, Molise and Apulia.

We give below some details about the two earthquakes which hit various villages in Southern Italy in August, 1962.

Irpinia-Sannio Earthquake of 21st August, 1962.- On 21st August, 1962 a series of earthquake shocks occurred in Irpinia and Sannio[3], with noticeable effects in the neighbouring regions also: two were more violent; the first, at $19^h\,09^m03^s$ caused everybody to abandon their houses; the second, much more violent, at $19^h\,19^m30^s$ was not responsible for any victims owing to the fortunate fact that the inhabitants, terrified by the preceding shock, had not yet returned to their houses. The shocks of 21st August

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(3) - Sannio is a geographical-historical unit which forms part of the present administrative provinces of Benevento (Campania) and Campobasso (Molise); Irpinia belongs to the administrative province of Avellino (Campania).

1962 caused great damage especially in numerous communes of the provinces of Avellino and Benevento: it is true there were no sudden collapses with loss of life, but the damage to structures was such that various buildings had to be demolished at once, others had to be cleared and many shored up (4). After 21st August several after-shocks, though only slight, worsened the conditions of the property already damaged on the 21st to such an extent that other families had to be evacuated and further emergency measures had to be taken.

About 400 communes were more or less damaged, distributed as follows: Campania (355): province of Avellino, 118 communes; province of Benevento, 33; province of Caserta, 81; province of Naples, 68; province of Salerno, 53. Molise (province of Campobasso): 50. Apulia (province of Foggia): 50.

According to the State Offices, the maximum degree (IX) was reached at Reino, Pietralcina, Molinara, Montecalvo, Ariano Irpino (for which there was talk of even a IX - X degree). The meizoseismal area, which cut across the provinces of Avellino, Benevento and Foggia, included Reino, Molinara, Ginestra degli Schiavoni, Casalbore, Colle S. Vito, Accadia, Melito, Bonito, Apice, S. Arcangelo Trimonte, Paduli, Pescosannita, Pago Veiano, Ariano and, not so badly hit, the Baronia district (Castel Baronia, S. Nicola B., etc.).

According to the Istituto di Fisica Terrestre of the University of Naples, the earthquake of 21st August, 1962, like other previous earthquakes, experienced a magnification on its arrival in the zone of Naples and surroundings.

D. DI FILIPPO and F. PERONACI (2) communicated the results of the study carried out on the intenser shocks of the "Irpinia-Sannio seismic period in August 1962"; they are given in table 1.

Damage caused by the earthquake of 21st August, 1962.- The three tables appended (2, 3 and 4) give a conspectus of the damage suffered by the built-up areas. The villages underlined in the tables were inspected by the Authors of this paper and their collaborators (5).

On these inspections particular attention was given to an examination of the engineering geology aspect of the local situations: geomorphology, hydrogeology, foundation

(4) - There were not 15 dead and 200 injured, nor the damage mentioned in B.S.S.A., 55, p. 213; (1963).

(5) - Pasquale Penta and Paolo Ammassari to whom we wish to express our gratitude here.

soils, types of foundations, degree of soil stability especially as regards creep, settlements, etc.

These inspections showed up the importance of the problem of mortar. Therefore the Authors took samples and made a study of old mortars and sands at present used for mortar.

With their examination of the places most hit by the earthquake, the Authors have also been able to weigh up the results of the censuses carried out previously by the Technical Offices of the State, and the reports of some Commissions which had inspected the damaged villages immediately after the earthquakes. Thus they were able to get a more immediate picture of the state of the places before the houses in a dangerous condition were demolished.

The following facts were ascertained regarding damage to other structures and engineering works:

a) Railway Tunnels.- No real damage to fairly deep tunnels.

b) Main Aqueducts.- No damage was done to the tunnels of the "Apulian" and "Campanian" aqueducts; in the distribution networks the damage was mostly due to the collapse of buildings over them and the consequent breaking of small road conduits.

c) Damage to State Roads.- There were no tunnelled sections in the zones affected by the earthquake. As regards structures above ground, there were only a few cases of damage, in general slight, to retaining walls, bridges and viaducts on some roads.

Earthquake (in Greece) of 28th August, 1962 which caused damage in Apulia.- The principal shock occurred at $11^h\ 59^m 48^s$ ($\phi_o = 37^\circ$ N, $\lambda_o = 22^\circ$ E, $h = 150$ km, magnitude 7 approx.) with epicentre in the Southern Peloponnese, and had a very wide macroseismic propagation.

In Italy it was felt with a VI degree intensity in some places in the provinces of Bari (Ruvo, Terlizzi), Brindisi (San Donaci, Mesagne, Latiano), Taranto (Manduria, Pulsano) and Lecce, and with a lower intensity in very many places in Southern Italy (from information kindly given by Prof. Mario De Panfilis).

Damage worth recording was suffered only by constructions (dwelling-houses, churches, other buildings, bridges, aqueducts, etc.) which were already weak or had been weakened by previous earthquakes.

II.- Observations.

The intensity of the earthquake of 21st August, 1962, estimated on the basis of the damage caused.- In estimating the intensity of the series of earthquake shocks of August, 1962, it does not appear that any objective details, apart from the percentages of houses more or less seriously damaged, were collected.

However, the constructions so damaged as to require total or partial demolition were almost exclusively of the very poor type predominant in the worst hit villages. On the basis of these data, the maximun intensity reached is between:
- 8° and 9° of the Rossi-Forel, Mercalli and Mercalli-Sieberg scales;
- 7° and 8° of the Mercalli scale several times modified, completed and made more specific, as for example by HOUSNER (3), KRYNINE and JUDD (4), RICHTER (8).
- It is certainly to be assigned to 7° on the new Russian scale proposed by MEDVEDEV, SPONHEUR and KARNIK.
- It falls within the field of degree
  ... III of the Oldham Scale
  ... III - IV " " Omori "
  ... V " " Scale of the Japanese Central Meteorological Observatory.

Checking of the "value" of the intensity (in degrees of the scale MM v. 1956) by means of "instrumental" data.- G.W. HOUSNER's tables (3) for 11 earthquakes in California (from 1933 to 1941) with a hypocentral depth of about 18 km (considerably less than that of the Irpinia earthquake being studied, about 40 km ± 15) and a magnitude varying between 5.3 and 6.7 (M of Irpinia earthquake was about 6.2) give maximum degrees (referred to those of the MM Scale)varying from 6° to 7 1/2° but not reaching 8°. According to C.F. RICHTER's table (8, p. 353) for the earthquakes in California (with perhaps not very deep hypocentres), with magnitude 6.2 and degree II isoseismal radius greater than 220 (at Rome, according to DI FILIPPO and PERONACI, the earthquake was felt at degree III) and less than 400 km, an intensity would be reached between 8° and 9°. The degree of maximum intensity, I, (between 6° and 8 1/2°) is also confirmed if we apply the empirical formulae of SHEBALIN and KARNIK, given by J.P. ROTHE' (11), which link I, M, and h, and for M = 6.2 approx. and h (depth of hypocentre which may vary from 25 to 55 km according to the calculations of DI FILIPPO and PERONACI) give:

$$I\ (\text{Shebalin}) = \begin{matrix} 6^\circ \text{ for } h = 55 \text{ km} \\ 7^\circ \text{ " " } = 25 \text{ km} \end{matrix} \qquad I\ (\text{Karnik}) = \begin{matrix} 8^\circ \text{ for } h = 55 \text{ km} \\ 8\ 1/2^\circ \text{ " " } = 25 \text{ km} \end{matrix}$$

We may, therefore, consider that the maximum intensity reached by the earthquake being studied (in built-up areas) was above 7°, but did not exceed 9° on the MM Scale.

The experience drawn from the Irpinia-Sannio earthquake of 1962 in relation to Italian earthquake legislation.- One of the writers outlined the difficulties met with in legislating for constructions to stand up to earthquakes, noting what a delicate task it is to

formulate or bring up to date simple, but not over-simplified nor excessively severe, regulations which are easy to follow, yet of use in the Earthquake Engineering field. In this sector the definite advances made in constructional technique are not yet matched by an adequate, soundly based knowledge of quick methods able to ensure the immediate stability and preservation of every type of structure, without undue expenditure, in areas frequently hit by violent earthquakes where, among other things, there are plenty of old constructions which have suffered many shocks: centuries-old houses, sometimes of historic or artistic interest, which have come through many earthquakes in the past (see table 5) and which, in the mean time, have become increasingly weaker, must be considered by the regulations as well as structures built in accordance with the most advanced modern techniques. On the subject of earthquake building in Italy, C.F. RICHTER (8) points out that in Southern Italy building goes on in the same way as before the great earthquake disasters of last and the beginning of this century: he points out the persistence of this state of affairs after the Irpinia earthquake of 1930, and notes that what R. MALLET (1862) had deplored, after the earthquake of 1857, still existed in 1930 at the time of the so-called "Vulture" earthquake. Against this it may be said that the earthquake of 1930 hit villages, built-up areas and buildings which, in general, had not been constructed after 1857, but only in part badly repaired after that earthquake (6). It is recognized, however, that bad construction must be avoided in areas subject to earthquakes and landslips too: if unfortunately other eartquake disasters occur, we must see to it that damage is limited to old buildings on bad foundations, badly made or badly reconstructed in the past, but that new constructions are not ruined.

Against the risk threatening old houses there is no remedy: we are not in a position to demolish them systematically; nor could we proceed on the basis of a list graded according to earthquake risk. Unless the gradual consolidation or reinforcement of old constructions worth it were decided on, particularly by strengthening the masonry (e.g. with cement injections as and where possible). On the other hand, new constructions properly carried out in villages subject to earthquakes should be freed from excessive, unjustified restrictions. Not only, that is, must we prevent construction and reconstruction with methods and materials which should be discarded even in places where there is no fear of earthquakes, but we also need to make better use of the means afforded by modern constructional techniques (especially reinforced concrete and steel), experimental technique and earthquake experience, in order to reduce the restrictions on new constructions and the natural development of technique to the indispensable minimum. Furthermore, it should be remenbered that the laws in force in Italy regarding reinforced concrete and metal constructions are more than effective and efficient.

The research carried out in the villages struck by the earthquake of August, 1962, has confirmed all this, and has shown the absurdity of the claim to legislate for constructions in general, solely on the basis of the seismic behaviour of old, constitutionally weak houses in poor condition which have, besides, been repeatedly strained through

the centuries by earthquake shocks (and, later, by shocks of other kinds), and by continual irresponsible alterations made by men.

III.- Conclusions.

The attached map shows the built-up areas which suffered most in the earthquake of 21st August, 1962. The studies carried out in them aimed principally at establishing: A) morphological and geological conditions; B) special characteristics of foundation soils; C) constructional techniques and materials used in constructions.

A) Influence of morphology and geology.- Almost all the communes inspected are situated on the tops of hills; therefore it was not possible to make comparisons regarding the seismic influence of any oscillation peculiar to the rises on which the villages are built. It was noticed that, where the sides of the hills are subject to landslides and related phenomena, the effects of the earthquake are accentuated. We did not find sure data on which to affirm that evident geological characteristics or differences in lithological types heightened or diminished the effects of the earthquake locally.

B) Foundations.- There was confirmation once again of the influence of foundation soil on the seismic behaviour of high structures: "looseness"due to remoulding and sometimes to fill, with consequent water seepage and severe settlements; variety of soils affecting a single foundation and, hence, the possibility of differential settlements; soils on steep slopes already near the equilibrium limit, or already in a state of slow creep as regards the thicknesses above the depth of the foundations.

C) Local construction techniques and methods.- The percentage of houses which actually collapsed in the earthquake was very low compared with the number of houses so seriously damaged as to require immediate demolition, some totally, others partially. The biggest damage was met with (6) in old houses of poor masonry characterized by fundamental deficiencies and further weakened or loosened by later alterations.

a) Fundamental deficiencies.- These deficiencies concern foundations, types of structures, the way they are built and the materials used. In these villages, in fact, the foundations are mostly shallow and sometimes actually uncovered; they almost always stop short within the "stratum" of soil susceptible to outside action and they often rest on heterogeneous soil. As regards types of structures, among other things, the following factors unfavourable to earthquake resistance were noticed: thrusting structures (heavy arches and vaults, all without tie rods and the like) without resistances, irregular distribution of empty spaces and solids, bluffs and overhangs of every type and dimension, masonry mostly executed in naturally slab-shaped stone (or evene in smooth-surfaced pebbles) on the face and with "sack" filling in the inside. In the humbler

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(6) - This confirms once again what has been found and repeatedly recorded for about two centuries.

houses which represent the majority of the ancient constructions and which suffered most, local building methods were followed which are unsatisfactory both as regards resistance to dynamic action and from the preservation aspect. As for the materials used, it must be noted that in old constructions timber was plentifully employed both in floors and roofs, and in the lintels of the rooms. During the earthquake shocks wooden beams and roof trusses acted as catapults against the walls, already weak and unstable in themselves.

b) Later alterations.- The repeated and irresponsible readaptations, height-raisings, openings-up of new rooms, shiftings of flues cut in the walls, additions of penthouses, etc. have made conditions worse.

c) Repairs.- Repairs, especially those carried out after the repeated earthquakes, have mostly been superficial, "formal" and not functional: e.g., the tie rods fixed have turned out ineffective and sometimes perhaps harmful. So that, notwithstanding the repairs, after every earthquake the mortar has become further enfeebled, the joints loosened, the continuity reduced, the foundation upset, and so on. If after the earthquake of 1930 the damaged buildings had been demolished instead of being repaired, the damage in the 1962 earthquake would,perhaps, have been less serious.

d) Mortar.- The mortar of the houses demolished was found to be completely lacking in cohesion; this condition was obvious in the mortar composing the basic "paste" of the "sack" filling of the masonry which remained standing after the parts considered dangerous had been demolished; the hands could be plunged into it as easily as into a loose sand, and the fragments of stone in it could be removed by hand without difficulty. This defect does not seem attributable to local factors, nor can it definitely be put down to an excessive percentage of "clayey" fraction in the sand used. The first granulometric and petrographic analyses, carried out on the mortar taken from the inside of the masonry and on some sands used today, leave doubts in the matter. Other factors might be concerned: subsequent deterioration of the mortar accentuated or accelerated by the earthquake shocks; faulty preparation at the outset as, for example, wrong proportions of quick-lime or of mixing water, quality of the latter, sand too dry, defective mixing; excessive speed or slowness in drying of the mortar in place (to the detriment of the carbonation process) due to a defective degree of permeability (to the air) of the mortar, etc. The fact that this drawback is so widespread makes the hypothesis of defective preparation less acceptable. Moreover, in some ancient buildings the mortar is somewhat better. However, this problem of the mortar must be studied, because defects in this were chiefly responsible for the gravity of the earthquake effects in the most ancient houses struck by the earthquake of 1962.

Factors which magnified the effects of the earthquake of 21st August, 1962.- No geological, morphological or constructional factors emerged from the inspection carried out which would lead us to attribute directly to any of them a substantial difference of "response" to the earthquake from village to village: as a rule these factors influenced

all the communes affected in an almost equal degree [7]. The greater extent of damage in some of them must, therefore, be attributed to a greater intensity of the earthquake in the subsoil of the locality concerned: to the greater nearness, that is, of the built-up area to the epicentral zone and, within this, perhaps to the distances from the numerous more or less active faults belonging to several systems: Apennine, Tyrrhenian, N-S, E-W or almost, etc. All these faults are Post-Pliocene or, at any rate, they have also been active after the Pliocene age, and they divide the whole region into a mosaic of patches with little or no stability [8]. With regard to the position of the epicentre, it is probable, as DI FILIPPO and PERONACI (2) suggest, that a deep regional fracture bearing 83° - 85° was determined or reactivated. It is deeply inclined with respect to the vertical which would be prolonged beyond the Adriatic. The numerous lithological types (from limestone, sandstone, marl, shale, chalk, etc. of varying capacities, to sand and gravel more or less cemented and of different ages, from the Eocene to the Upper Pliocene, the complicated structure (in folds, but predominantly in faults and creeps), the attitude of the different formations variable even within small areas and the extreme degree of discontinuity, preclude a direct reconstruction of the relations between local geology and the corresponding extent of the shock. Reconstruction is also made difficult by the repetition of rocks which are of a similar kind from the macro-lithological point of view, but belong to different stratigraphic complexes. We would point out again that, the original local shock being equal, the state of disequilibrium or precarious equilibrium already existing (creeps and landslides), the tendency of the foundation soil to differential settling, the age of the constructions, the poor or very bad constructional types, especially when they are associated, etc., accentuated the damage in groups of houses or even in individual houses.

The 1937 Earthquake Code as tested by the 1962 earthquake. - We may say:

1. The anti-earthquake regulations of R.D. 22 XI 1937 had been applied. In smaller repairs, however, the unsuitable local building customs had been followed.

2. The 1937 Code answered the purpose. But the intensity of the earthquake, how-

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(7) - This is true of the communes in which the shock was from VII-IX degrees. At a distance from the epicentral area some anomalies, e.g. the one already mentioned about Naples, might be attributed to local or even regional geological characteristics.

(8) - This is the picture directly resulting from the unpublished studies of G. BARTOLUCCI (of the Institute of Applied Geology of the Engineering Faculty of Rome University, 1951-52) and those of A. RITTMANN (9) and (10) and G. DESSAU (1).

ever severe as regards the "poor" houses, was not such as to test the regulations in their applications to the larger buildings for which they had been drawn up.

Where the intensity was severe (i.e. in the epicentral area, which was also determined with instruments), the old constructions, which had remained standing after previous earthquakes, suffered serious damage because of constructional defects and, above all, because of the lack of cohesion in the mortar. As a rule, the new constructions did not suffer notable damage. The modern constructions, especially those of reinforced concrete, but also those of masonry executed in accordance with the 1937 Earthquake Code, in general stood up well to the earthquake. This caused only slight damage where the masonry joins the bearing structures and, in general, only the breaking off of plaster even where the shock was more intense. Those old constructions also behaved satisfactorily in which better quality materials and better constructional methods were used.

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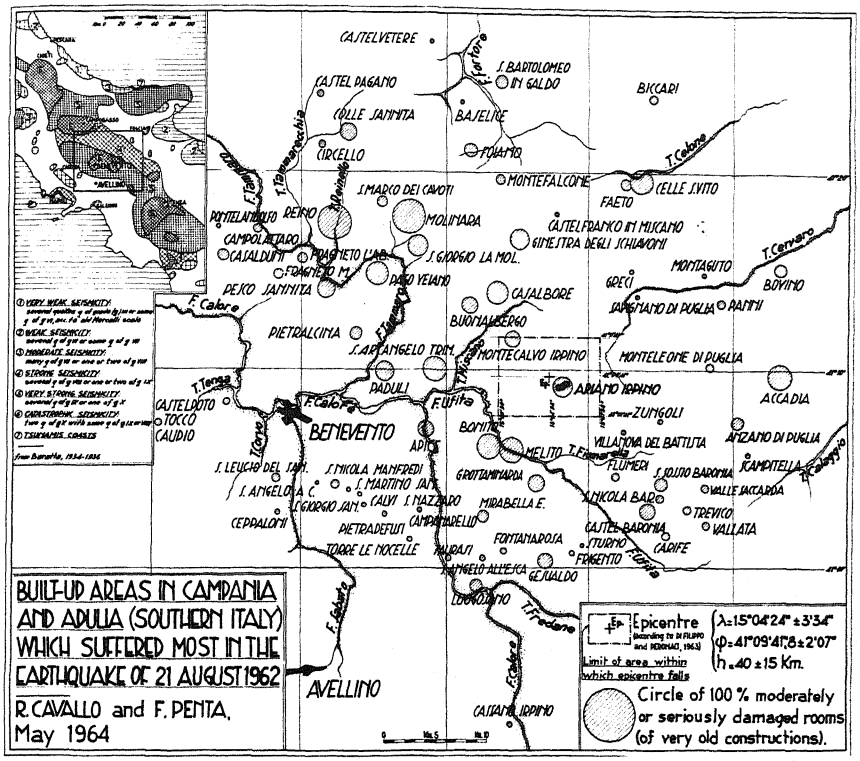

Table 1.- Earthquake shocks of 21-22 August, 1962 in Irpinia and Sannio (according to DI FILIPPO and PERONACI, 1963).(1)

	Day	Time registered at Rome	Magnitude	Energy liberated (erg)
1)	21 - 8	$15^h\ 56^m\ 22^s$	4,52	$7,05 \cdot 10^{18}$
2)	"	18 08 24	4,38	$3,65 \cdot 10^{18}$
3)	"	18 09 43,5	5,86	$5,38 \cdot 10^{21}$
4)	"	18 20 05,5	6,18	$2,61 \cdot 10^{22}$
5)	"	18 45 29	4,49	$9,33 \cdot 10^{18}$
6)	"	20 08 57	4,05	$7,03 \cdot 10^{17}$
7)	"	21 28 35,5	3,94	$4,00 \cdot 10^{17}$
8)	"	23 36 37,5	3,56	$6,21 \cdot 10^{16}$
9)	"	23 40 57	3,46	$3,88 \cdot 10^{16}$
10)	22 - 8	02 05 25,5	3,36	$2,27 \cdot 10^{16}$

(1) - For the earthquakes of numbers 1, 3 and 4 respectively the Authors calculate the following values of the hypocentral coordinates.

	φ_o	λ_o	h
1)	41° 07' 43" N	15° 06' 57" E	35,5 km
2)	41° 10' 16" N ± 0° 03' 00", 5	15° 06' 57" E ± 0°01' 41", 5	49,45 km ± 18,11
3)	41° 09' 41",8 N ± 0°02'00",7	15° 04' 24",2 E ±0°03'34",0	39,76 km ± 14,88

TABLE 2 - VILLAGES MOST DAMAGED BY EARTHQUAKE OF 21 AUGUST 1962

PROVINCE OF AVELLINO	CLASS (o)	No. of inhabitants (approx.)	ROOMS		HOUSES						
			No. rooms before (approx.)	% rooms moderately or seriously damaged (approx.)	No. houses before (approx.) (A)	Habitable	Slightly damaged	Uninhabitable but repairable	Uninhabitable not repairable (B)	To be demolished (C)	$\frac{B+C}{A} \cdot 100$
1. ARIANO IRPINO (*)	I	30.000	21.000	45	4.400	400	1.800	1.100	200	900	25
2. BONITO	(.)	4.000	4.000	50	1.000	--	300	150	100	400	50
3. CARIFE	I	3.000	3.000	15	.	.	.	.	.	.	.
4. CASALBORE	(.)	3.000	2.500	50	800	50	350	100	--	300	40
5. CASSANO IRPINO	(..)	2.000	2.000	5	.	.	.	.	.	.	.
6. CASTEL BARONIA	I	2.000	1.500	30	500	50	200	150	50	50	20
7. FLUMERI	I	3.500	2.500	20	500	--	350	50	50	50	20
8. FONTANAROSA	(..)	5.000	4.000	10	.	.	.	.	.	.	.
9. FRIGENTO	(..)	6.000	4.500	--	.	.	.	.	.	.	.
10. GESUALDO	(..)	7.000	5.500	40	.	.	.	.	.	.	.
11. GRECI	(..)	2.500	3.000	--	200	--	150	50	--	--	.
12. GROTTAMINARDA	II	8.000	6.500	40	.	.	.	.	.	.	.
13. LUOGOSANO	(..)	2.000	1.500	30	.	.	.	.	.	.	.
14. MELITO IRPINO	I	3.000	2.500	50	800	50	200	200	50	300	45
15. MIRABELLA ECLANO	II	10.000	9.500	25	.	.	.	.	.	.	.
16. MONTAGUTO	II	1.500	1.500	5	200	--	150	50	--	--	.
17. MONTECALVO IRPINO	I	6.000	5.000	35	1.600	150	400	500	100	450	35
18. PIETRADEFUSI	II	4.000	3.500	10	.	.	.	.	.	.	.
19. S. ANGELO ALL'ESCA	(..)	2.000	20.000	10	.	.	.	.	.	.	.
20. S.ARCANGELO TRIMONTE	II(.)	10.000	1.500	60	400	--	150	100	100	50	50
21. S. NICOLA BARONIA	I	1.000	1.000	20	500	50	200	50	--	70	15
22. S. SOSSIO BARONIA	I	2.500	2.500	25	450	--	350	100	--	--	0
23. SAVIGNANO	I	3.000	3.000	--	100	50	50	--	--	--	0
24. SCAMPITELLA	(.)	2.000	1.500	5	.	.	.	.	.	.	.
25. STURNO	II	4.000	3.500	--	.	.	.	.	.	.	.
26. TAURASI	II	3.000	3.000	5	.	.	.	.	.	.	.
27. TORRE LE NOCELLE	(..)	2.000	2.500	5	.	.	.	.	.	.	.
28. TREVICO	I	1.500	1.500	15	400	50	250	50	--	50	10
29. VALLATA	I	5.000	4.500	15	850	--	600	150	--	100	10
30. VALLESACCARDA	(.)	2.000	2.000	20	400	50	200	100	50	--	10
31. VENTICANO	(..)	3.000	3.000	5	.	.	.	.	.	.	.
32. VILLANOVA DEL BATTISTA	I	3.000	2.500	5	200	50	100	--	50	--	25
33. ZUNGOLI	I	2.000	2.000	--	150	50	100	--	--	--	0

(o) Class assigned to in accordance with Law of 22 November, 1937

(*) Villages underlined were also inspected by the Authors

(.) Later changed to Class I

(..) Later changed to Class II

TABLE 3 - VILLAGES MOST DAMAGED BY EARTHQUAKE OF 21 AUGUST 1962

PROVINCE OF BENEVENTO	CLASS (o)	No. of inhabitants (approx.)	ROOMS		HOUSES						
			No. rooms before (approx.)	% rooms moderately or seriously damaged (approx.)	No. houses before (approx.) (A)	Habitable	Slightly damaged	Uninhabitable but repairable	Uninhabitable not repairable (B)	To be demolished (C)	$\frac{B+C}{A} \cdot 100$
1. APICE (*)	II(.)	7.000	7.000	30	1.900	500	850	200	250	50	15
2. BASELICE	(..)	4.000	3.000	10	.	.	.	.	.	.	.
3. BUONALBERGO	II(.)	3.000	3.000	30	800	150	400	--	300	--	35
4. CALVI	(..)	4.000	3.000	5	.	.	.	.	.	.	.
5. CAMPOLATTARO	(..)	2.000	2.000	10	.	.	..	.	.	.	.
6. CASALDUNI	(..)	2.500	2.500	10	.	.	.	.	.	.	.
7. CASTELFRANCO IN. M.	(..)	2.000	1.500	5	.	.	.	.	.	.	.
8. CASTEL PAGANO	(..)	2.500	3.000	20	.	.	.	.	.	.	.
9. CASTELPUOTO	(..)	2.000	2.000	15	.	.	.	.	.	.	.
10. CASTELVETERE IN V. F.	(..)	4.000	3.500	5	.	.	.	.	.	.	.
11. CEPPALONI	(..)	5.000	5.500	15	.	.	.	.	.	.	.
12. CIRCELLO	(..)	4.000	3.500	10	.	.	.	.	.	.	.
13. COLLESANNITA	(..)	4.500	4.000	35	.	.	.	.	.	.	.
14. FOIANO VALFORTORE	(..)	2.500	2.500	30	.	.	.	.	.	.	.
15. FRAGNETO L'ABATE	(..)	2.000	2.000	10	.	.	.	.	.	.	.
16. FRAGNETO MONFORTE	(..)	2.500	3.000	10	.	.	.	.	.	.	.
17. GINESTRA DEGLI SCHIAV.	(.)	1.000	1.000	50	350	--	150	100	50	50	30
18. MOLINARA	(.)	2.500	4.000	70	1.250	50	300	400	300	200	40
19. MONTEFALCONE	(..)	3.500	3.000	15	.	.	.	.	.	.	.
20. PADULI	(.)	5.000	4.500	50	1.500	100	700	100	450	150	45
21. PAGO VEIANO	(.)	3.000	3.000	40	1.000	--	600	100	200	100	30
22. PESCO SANNITA	(.)	3.000	3.000	40	1.000	100	500	50	300	50	35
23. PIETRELCINA	(..)	4.000	4.000	30	1.200	200	600	100	200	100	25
24. PONTE LANDOLFO	(..)	6.500	6.000	10	.	.	.	.	.	.	.
25. REINO	(.)	2.000	2.000	70	500	--	150	--	200	150	70
26. S. BARTOLOMEO IN GALDO	(..)	10.000	8.000	30	.	.	.	.	.	.	.
27. S. GIORGIO DEL SANNIO	II	6.000	5.500	5	.	.	.	.	.	.	.
28. S. GIORGIO LA MOLARA	(..)	6.000	5.000	40	1.500	100	700	300	150	250	25
29. S. LEUCIO DEL SANNIO	(..)	4.000	4.500	10	.	.	.	.	.	.	.
30. S. MARCO DEI CAVOTI	(..)	5.000	7.000	20	1.100	300	450	100	250	50	30
31. S. MARTINO SANNITA	(..)	2.000	2.000	10	.	.	.	.	.	.	.
32. S. NAZZARO	(..)	1.000	1.000	15	.	.	.	.	.	.	.
33. S. NICOLA MANFREDI	(..)	3.500	3.000	20	.	.	.	.	.	.	.
34. S. ANGELO A CUPOLO	(..)	4.000	4.500	10	.	.	.	.	.	.	.
35. TOCCO CAUDIO	II	2.000	2.000	15	.	.	.	.	.	.	.

(o) Class assigned to in accordance with Law of 22 November, 1937

(*) Villages underlined were also inspected by the Authors

(.) Later changed to Class I

(..) Later changed to Class II

Table 4.- Villages of the province of Foggia damaged by the earthquake of 21 VIII 1962.(1)

Seriously hit	Moderately hit	Slightly hit
1) - Accadia (40) (2)	1) - Alberona (2)	1) - Apricena
2) - Anzano di P.	2) - Carlantino	2) - Carpino
3) - Ascoli Satriano	3) - Casalnuovo Monterotaro	3) - Manfredonia
4) - Biccari (14)	4) - Castelluccio dei Sauri	4) - Margherita di Savoia
5) - Bovino (31)	5) - Celenza Valfortore	5) - Mattinata (2)
6) - Candela	6) - Cerignola	6) - Monte S. Angelo
7) - Castelluccio Valfortore (maggiore ? 8)	7) - Foggia	7) - S. Giovanni Rotondo
8) - Celle S. Vito	8) - Lucera	8) - S. Marco in Lamis
9) - Deliceto	9) - Motta Montecorvino	9) - S. Nicandra Garganico
10) - Faeto (8)	10) - Ortanova	10) - Stornarella
11) - Orsara di P. (4 o 2)	11) - Pietra Montecorvino	
12) - Panni (1)	12) - San Ferdinando di Puglia	
13) - Rocchetta S. Antonio	13) - S. Severo	
14) - Roseto Valfortore (1)	14) - Serracapriola	
15) - S. Agata di Puglia	15) - Volturara Appula	
16) - Troia (4)	16) - Volturino	

(1) - The following communes must be added: Canpelle, Chieuti, Monteleone di Puglia, S. Marco la Catola, S. Paolo Civitale, Trinitapoli, Vico Garganico, Vieste. Therefore the total number of communes in the province of Foggia damaged by the earthquake of 21 August, 1962, was about 50.
For many communes the number of houses evacuated is shown in brackets; for the province as a whole they amounted to about 100 (96).

(2) - The village most seriously damaged was Accadia in a zone from which already (from 1933) it had been decided to transfer the population. It was inspected by Eng. P. Ammassari, a collaborator of the Authors'.

Table 5.- Years in which severe shocks occurred in the 18 villages worst hit by the earthquake of 21 August, 1962.

YEAR	990	1180	1349	1456	1688	1694	1702	1732	1794	1805	1885	1899	1904	1905	1930	1933	1950
Apice				yes	yes		yes	yes			yes	yes	yes	yes	yes		yes
Ariano Irpino	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes				yes	yes	yes	
Bonito Irpino					yes		yes	yes									
Buonalbergo								yes			yes				yes		
Casalbore								yes									
Colle Sannita										yes			yes		yes		
Foiano Val Fortore					yes			yes		yes							
Ginestra degli Schiavoni								yes									
Grottaminarda					yes	yes	yes	yes						yes	yes	yes	
Melito Irpino					yes		yes	yes							yes		
Mirabella Eclano				yes	yes	yes	yes	yes		yes				yes	yes		
Molinara					yes			yes		yes							
Montecalvo Irpino				yes	yes			yes						yes	yes	yes	
Pago Veiano							yes	yes			yes						
Pietrelcina					yes		yes	yes		yes					yes		yes
Reino					yes			yes		yes							
S. Arcangelo Trimonte										yes					yes		yes
S. Giorgio La Molara					yes		yes	yes		yes					yes		