# Intensity assessment from documentary data

## Criteria and procedures in the daily practice of seismologists (*)

**Andrea Moroni** [1], **Giancarlo Monachesi** [2] **and Dario Albarello** [3]
[1] *Istituto di Ricerca sul Rischio Sismico, C.N.R., Milano, Italy*
[2] *Osservatorio Geofisico Sperimentale, Macerata, Italy*
[3] *Dipartimento di Scienze della Terra, Università di Siena, Italy*

**Abstract**
A major problem in assessing macroseismic intensity from historical records is the lack of a standardized procedure for processing documentary sources and supplying unequivocal intensity estimates. In fact, most macroseismic scales do not include detailed descriptions of procedures for intensity assessment and many divergent interpretations of intensity values are obtained by different operators. In order to disclose these problems an experiment was made in Italy in 1994, in the framework of GNDT «Seismicity» Working Group. A set of selected documents concerning original descriptions of effects produced by earthquakes which had occurred in Italy from 15th to 20th century, was supplied to a number of independent researchers. Each of them was invited to assess on this basis the intensity values and to explain his intellectual path by describing it in detail. This documentation was finally collected and, during a meeting devoted to this topic, the researchers involved were invited to discuss their personal experiences. The discussion indicated that the discrepancies between the estimates obtained by the different authors from the same documentary source are, in many cases, greater than 1 degree. This implies that the effect of personal choices may play an important role in intensity assessment and makes intensity estimates performed by the different authors less comparable. At present no definitive conclusions about these problems can be drawn but the topics focused during the meeting may represent a useful basis for a wider discussion to define a standardized procedure for the assessment of intensity from documentary data.

**Key words** *earthquake – macroseismic scales – historical records*

## 1. Introduction

The problems in assessing intensity from historical records are well known: reliability of the sources, the definition of context in which the report appears, completeness of the data and so on. Recently, the methodological problems in processing historical earthquake records have been pointed out (Stucchi, 1993; Guidoboni and Stucchi, 1993; Stucchi, 1994) and some interpretative problems concerning intensity assessment from damage reports have been discussed (Moroni and Albini, 1993). However, a major problem remains concerning the lack of a standardized procedure for processing documentary data to perform intensity estimates. The most used scales (MCS, MSK-64 and MSK-81) do not supply a guide-line for intensity assessment and some partial indications in this sense have only been included in the new EMS-92 scale (Grünthal, 1993). To face this problem, in recent years, some at-

*Mailing address*: Dr. Andrea Moroni, Istituto di Ricerca sul Rischio Sismico, C.N.R., Via Ampère 56, 20131 Milano, Italy; e-mail: andrea@dandrea.irrs.mi.cnr.it

(*) From a test carried out in the frame of GNDT, Italy, «Seismicity» Working Group.

**Table I.** The set of selected documents concerning original descriptions of earthquake effects supplied to each participant in the experiment (in bold the cases analyzed in detail).

| Earthquake | Question | Type of record | Characteristics |
|---|---|---|---|
| 04.26.1458, Città di Castello (Perugia) | Assess intensity at Città di Castello. | Global damage is reported. No data on types of structures. Information on population. | Representative of detailed description. Excellent medieval source. |
| Aug.-Sept. 1467, Siena | Assess intensity at Siena. | Ambiguous description: damage or not? | Representative of uncertain information, slight damage? |
| **03.04.1505, Cupramontana (Ancona)** | **Assess intensity at Cupramontana.** | **Synthetic description, no information about effects.** | **Representative of very synthetic information. Problem to use «Felt».** |
| 10.07.1639, Amatrice (Rieti) | Assess intensity at the 25 localities reported. | Synthetic description of damage. | Representative of synthetic information on damage in many localities. |
| 04.24.1741, Fabriano (Ancona) | Assess intensity at Scisciano. | Detailed description of damage to buildings. Estimated number of buildings from number of habitants. No data on types of structures. | Representative of detailed survey of damage at each building. |
| 06.03.1781, Monte Uliveto Maggiore (Siena) | Assess intensity at Monte Uliveto Maggiore. | Detailed description of effects of low intensity. | Representative of detailed description of effects on people and object. |
| **04.24.1741, Fabriano (Ancona)** | **Use at best the information available.** | **Very detailed description of damage at a palace: damage in each room is described.** | **Representative of very detailed damage survey at one building.** |
| 02.1657, Iesi (Ancona) | Use at best the information. | Generical information of collapse of a building, maybe an earthquake. | Representative of uncertain information. |
| 1874 and 1875, Marches and Umbria | Assess intensity at the 6 localities reported. | Synthetic description of effects. | Representative of the information present in the seismological bulletins. |
| 1530, Siena; 04.13.1558, Siena | Assess intensity at Siena of the two earthquakes reported. | Description of slight damage for the 1558 event; the effects of the 1530 one are reported only comparatively with them of 1558. | Representative of a description of effects made comparing two earthquakes. |
| **05.06.1976, Friuli** | **Assess intensity at three localities.** | **Data organized to use MSK scale.** | **Representative of recent data already organized.** |
| **03.12.1873, Fabriano (Ancona)** | **Assess intensity at Fabriano.** | **Detailed description of the effects on more indicators present in the scale.** | **Representative of a detailed description of effects on people, objects and buildings.** |
| 01.30.1901, Salò (Brescia) | Assess intensity at Salò, Desenzano, Isola de' Ferrari, Cantù. | Reported only intensity values expressed in the Mercalli scale of ten degrees. Annexed a paper where Mercalli explains his scale. | Representative of information in old scales intensity value. |
| 01.11.1848, Augusta (Catania) | Assess intensity at Augusta. | Detailed description of damage at a sicilian locality. | Representative of a detailed description of damage. |

tempts have been made to delineate more or less formalized procedures for intensity assessment (Barbano and Salemi, 1992; Albarello, 1992; Barbano, 1993; Monachesi and Moroni, 1993; Padula *et al.*, 1993; Ferrari *et al.*, 1995; Lambert *et al.*, 1994; Moroni, 1994). However, since no general agreement exists about the procedure, these attempts only delineate a number of possible «rules» or formal tools to express the «standard procedure» which has to be defined on the basis of a general agreement.

In this context, a better insight into the daily practice of users becomes necessary to understand the level of agreement between the researchers and to assess the degree of comparability between intensity estimates performed by the different authors. This is of paramount importance in Italy where a very large data base, containing more than 25000 intensity estimates performed by a number of independent authors, is being collected.

## 2. An experiment

In order to analyze this kind of problem an experiment was performed in Italy in 1994, in the framework of GNDT «Seismicity» Working Group. The goal was to discuss and compare the procedures and criteria usually adopted by Italian operators in assessing intensity. The way to tackle these problems was the discussion of some historical cases. In July 1994, each participant was supplied with a set of selected documents concerning original descriptions of earthquake effects in various periods (from 15th to 20th century). Each researcher was invited to assess the intensity values and to explain his intellectual path by describing it in detail. This documentation was finally discussed during a meeting to collect the widest possible set of personal experiences.

The historical cases selected were 14 (table I). Each of them comprises the original text and, in few cases, some side information (*e.g.*, estimated number of buildings at the site, population etc.). In some cases these supplementary data were not supplied at the beginning, trying to stimulate precise requests from participants.

**Table II.** Participants in the experiment.

| | Invited | Present at the meeting | Written solutions |
|---|---|---|---|
| Geologists | 13 | 3 | – |
| Historians | 5 | 5 | 1 |
| Seismologists | 21 | 12 | 4 |
| Mathematicians | 8 | 6 | 1 |
| Engineers | 6 | 3 | 2 |

In the choice of these historical records, the starting point was the collection of a representative set of the most frequent descriptive typologies which are actually encountered in practice. In order to make this set as representative and complete as possible, a classification of the most frequent documentary situations was attempted.

Two main typologies were identified and concern the level of details involved in the available description of seismic effects. This characterisation does not reflect the age of referenced documents since many data about recent earthquakes can be considered more synthetic than older ones. A second characterisation concerns the presence/absence of damage described in the source. This distinction partially overlaps the previous one since, in general, damaging earthquakes are better documented. However, better documentation for damaging earthquakes is not the rule. The selection includes documentary sources covering a large time interval from the middle ages to 20th century.

Seventy researchers involved in intensity assessment or in the use of intensity for hazard and risk estimates were invited to participate in the experiment; 53 of them agreed to participate and received the selected documentary sources for intensity assessment (table II).

## 3. Cases discussed

The discussion tackled several cases, but four of them have been analyzed in detail as representative of the most important aspects of

the intensity assessment procedures. These 4 cases were: a synthetic historical record of the effects of the March 4, 1505 Central Italy earthquake in the locality of Cupramontana; a detailed report of the effects in Fabriano of the March 12, 1873 Marches Italian region earthquake; data provided by a survey of damage produced by the May 6, 1976 Friuli earthquake in three localities; a very detailed description of the damage to the government palace of Fabriano after the April 24, 1741 earthquake.

### 3.1. *A synthetic historical record of the effects in the locality of Cupramontana (1505 earthquake)*

The notary Francesco Angelelli, who lived in Cupramontana (Ancona, Italy), wrote as a marginal note to his register between two deeds:

> *«(...) Die 4 mensis Martij Anni MDV circa horam meridianam fuit terremotus (...)»* (ASAn, 1505).
>
> *[March 4, 1505, at 12 o'clock circa, an earthquake occurred].*

The notary did not write anything more about the earthquake. No other testimony is known about this event.

This information is representative of a recurrent descriptive typology. In this case the source does not report either the locality, or the effects of the earthquake. About the «where» of the earthquake, all the participants have presumed that the information concerns Cupramontana. Since the writer lived in Cupramontana, if the event had occurred in another place, probably he would have specified it.

The participants showed little agreement about the evaluation of the effects of this earthquake. During the meeting the discussion showed that this kind of information is usually interpreted as a report of no damage and a «Felt» is assessed. But if this information is the only one in the seismic history of a locality, as in the case of Cupramontana, it can be important anyway to assess an intensity value. In this case, the intensity values estimated by the participants in the meeting have been summarized in table III.

**Table III.** 1505 earthquake: intensity values at Cupramontana proposed by the participants in the experiment.

| Number of proposer | MSK intensity proposed |
|---|---|
| 3 | IV-V |
| 3 | III-V |
| 5 | III-IV |
| 7 | II-V |
| 3 | II |
| 3 | *F* |
| 1 | $F \leq I \leq$ historical maximum |
| 2 | no value |

Five participants did not assess any value, preferring to get the record lost rather than to assess an intensity value from this kind of information. One proposal ($F \leq I \leq$ historical maximum) was similar to the assessment of an intensity range of II-XII since, in this case, the event is the only one reported in the Cupramontana seismic history.

The other 21 participants assessed 5 different values in general spanning between II and V. This means that, in general, these researchers assumed that the lack of information about damages implies that no significant damage occurred.

### 3.2. *A detailed report of the effects in Fabriano (1873 earthquake)*

The source (Serpieri, 1873) reports:

> *«[...] March 12, 1873 at 9:05 [...]. A lot of glasses were in line in a cupboard, two of them fell towards South-West. A stick fell in the same direction and also many bottles and vases in a chemical laboratory fell towards South-West [...]. People were frightened very much and ran outdoors. Many people slept in the open [...]. Cases of damage were in great number and notable. In several houses chimneys fell down [...]. Inside the city walls collapsed about thirty chimneys [...]. There are no houses in Fabriano without cracks and fissures [...]».*

It is a very detailed description: the effects on objects, people and buildings are reported. Most participants agreed that information on objects and people are less significant than the ones on buildings. Thus, the discussion focused on the description of damage and on this basis the intensity assessment was attempted in the framework of MSK-81 and EMS-92 scales. For this purpose, information on buildings and damage have been reorganized in:

- buildings typology;
- percentage of damaged buildings;
- distribution of damaged buildings in the grades of damage.

To assess MSK-81 intensity at Fabriano, most participants assumed that buildings were B-type. It has been objected that, usually, similar suppositions are not advanced in the cases of earthquakes which occurred only one century before. It seems that this evaluation is influenced by the fact that many 19th century buildings exist today. In any case, also the hypothesis that A-type buildings were present was explored. In particular, two extreme cases were analyzed assuming respectively that all buildings were of B-type and that all of them were of A-type. The total number of buildings (3000 *ca.*) are known from census sources.

**Table IV.** Effects in Fabriano of the 1873 earthquake: the damage distribution proposed by the participants and that is present in the MSK-81 scale (hypothesis all buildings of B-type).

| 1873 earthquake distribution of damage in Fabriano proposed | | | | | | | MSK - 81 scale | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of proposer | Build. type | Damage degree | | | | | | Build. type | Damage degree | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | 1 | 2 | 3 | 4 | 5 |
| 1 | B | | many | | | | VI | B | single | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | 1 | 2 | 3 | 4 | 5 |
| 7 | B | few | many | few | | | VII | B | | many | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | 1 | 2 | 3 | 4 | 5 |
| 4 | B | many | few | | | | VIII | B | | | many | few | |
| | | 1 | 2 | 3 | 4 | 5 | | | 1 | 2 | 3 | 4 | 5 |
| 2 | B | most | few | | | | IX | B | | | | many | few |
| | | 1 | 2 | 3 | 4 | 5 | | | 1 | 2 | 3 | 4 | 5 |
| 1 | B | most | | many | | | X | B | | | | | many |
| | | 1 | 2 | 3 | 4 | 5 | | | | | | | |
| 1 | B | many | many | few | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | | | | | |
| 8 | B | | most | few | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | | | | | |
| 2 | B | | many | many | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | | | | | |
| 1 | B | | all | | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | | | | | | | |
| 1 | B | many | many | | | | | | | | | | |

The record on the 1873 earthquake states that, in Fabriano, «the damage was in a great number and notable»; «in several houses the chimneys fell down»; «there is not house without cracks or fissures»; «in the city are fallen thirty chimneys». The problem is how different operators interpret this information, if the reformulation of historical record in the terms of «few», «many» and «most» and their distribution in the grade of damage is the same for all the operators or not. In order to verify this aspect, each participant was asked to detail their distribution of quantities of damaged buildings.

Table IV shows the results of this test on the assumption that all the buildings were of type B. Starting from the same information 28 researchers gave 10 different distributions. Only one of these configurations, proposed by one researcher only, coincides with the scale descriptions (VII MSK). All the other distributions contain elements that belong to at least two degrees of the scale.

Participants were then asked to assess an intensity value at each distribution proposed. Table V shows the answers to this question. Leaving out the only distribution coinciding with the one in the scale, participants hardly agreed. In the evaluation of each distribution, two positions emerged: to assess an unequivocal value or to assess only intensity ranges. These two positions were not always maintained by the same participant, but each operator modified his/her evaluation depending on the distribution considered. The discussion disclosed two points of view:

– the first states that, in the case of a distribution with effects of one degree (*e.g.*, many buildings with damage 2, corresponding to the VII MSK) and elements of the upper one (*e.g.*, many buildings with damage 3, partially corresponding to VIII MSK) this uncertainty has to be taken into account and an intensity range (VII-VIII) has to be given;

– the second states that, in a similar case, it is possible to assign a degree only if the *whole* set of diagnostics described for that degree is actually observed; otherwise, the degree immediately lower should be assigned. Thus, in the case considered above, intensity VII MSK should be assessed.

Those adopting the first point of view (the majority of participants) try to save all the information, even if the resulting estimate is affected by a 2 degree uncertainty. Those adopting the second point of view assign only one

**Table V.** Intensity values (MSK-81) for each damage distribution proposed for Fabriano (hypothesis all structure B-type).

| | | 1873 earthquake: distribution of damage in Fabriano proposed | | | | | Intensity (MSK-81) proposed | |
|---|---|---|---|---|---|---|---|---|
| Number of proposer | Build. type | Damage degree | | | | | Minimum proposed | Maximum proposed |
| | | 1 | 2 | 3 | 4 | 5 | | |
| 1 | B | | many | | | | VII | |
| 7 | B | few | many | few | | | VII | VII-VIII |
| 4 | B | many | few | | | | VI | VI-VII |
| 2 | B | most | few | | | | VI | VI-VII |
| 1 | B | most | | many | | | VII-VIII | VIII |
| 1 | B | many | many | few | | | VII | VII-VIII |
| 8 | B | | most | few | | | VII | VII-VIII |
| 2 | B | | many | many | | | VII | VII-VIII |
| 1 | B | | all | | | | VII | VII-VIII |
| 1 | B | many | many | | | | VI | VI-VII |

intensity value but lose the information on the heavy damage.

In the hypothesis that all buildings are of type A, the evaluations on distributions of quantities in the grade of damage are not modified, but this hypothesis changes the final intensity estimates. Table VI shows the intensity values assessed by the participants in this case. Examination of tables V and VI suggests that intensity estimates supplied by the participants for this earthquake span on the range VI-VIII degrees MSK-81.

The EMS-92 scale presents a more coherent distribution of damage to buildings than the ones given in the MSK. This fact partially improves the intensity estimates for Fabriano (table VII). It is important to stress that the participants in the experiment had fewer diffi-

**Table VI.** Intensity values (MSK-81) for each damage distribution proposed for Fabriano (hypothesis all structure A-type).

| | | 1873 earthquake: distribution of damage in Fabriano proposed | | | | | Intensity (MSK-81) proposed | |
|---|---|---|---|---|---|---|---|---|
| Number of proposer | Build. type | Damage degree | | | | | Minimum proposed | Maximum proposed |
| | | 1 | 2 | 3 | 4 | 5 | | |
| 1 | A | | many | | | | VI | VI-VII |
| 7 | A | few | many | few | | | VI | VI-VII |
| 4 | A | many | few | | | | VI | – |
| 2 | A | most | few | | | | VI | – |
| 1 | A | most | | many | | | VI | VI-VII |
| 1 | A | many | many | few | | | VI | VI-VII |
| 8 | A | | most | few | | | VI | VI-VII |
| 2 | A | | many | many | | | VII | – |
| 1 | A | | all | | | | VI | VI-VII |
| 1 | A | many | many | | | | VI | – |

**Table VII.** Intensity values (EMS-92) for each damage distribution proposed for Fabriano (hypothesis all structure B-type).

| | | 1873 earthquake: distribution of damage in Fabriano proposed | | | | | Intensity (EMS-92) proposed | |
|---|---|---|---|---|---|---|---|---|
| Number of proposer | Build. type | Damage degree | | | | | Minimum proposed | Maximum proposed |
| | | 1 | 2 | 3 | 4 | 5 | | |
| 1 | B | | many | | | | VI | VI-VII |
| 7 | B | few | many | few | | | VII | – |
| 4 | B | many | few | | | | VI | – |
| 2 | B | most | few | | | | VI | – |
| 1 | B | most | | many | | | VII | VII-VIII |
| 1 | B | many | many | few | | | VII | – |
| 8 | B | | most | few | | | VII | – |
| 2 | B | | many | many | | | VII | VII-VIII |
| 1 | B | | all | | | | VI | VI-VII |
| 1 | B | many | many | | | | VI | VI-VII |

culties in using the EMS quantities because they are more flexible and present overlapping ranges. The estimates supplied by the participants again span in the range VI-VIII but a better agreement exists between the individual estimates.

### 3.3. *A survey of damage produced by the May 6, 1976 Friuli earthquake in three localities*

The source presents the results of a survey made by a group of engineers one week after the earthquake. Their goal was the validation of the MSK scale as a realistic representation of a damage situation. In particular, the percentages of damage for each type of buildings were explored in detail. Actually, the conditions for the application of this scale were not fully respected since buildings and damage typologies used in this survey differ from the standard one proposed in the scale. Three type of buildings, called G1, G2 and G3, were considered:

G1: old buildings, restored buildings and recent buildings with stone bearing walls;

G2: structures with concrete blocks and bearing walls made with bricks or prefabricated blocks;

G3: reinforced concrete buildings.

Instead of the five grades damage classification provided by the MSK-81 scale, only three grades were considered:

– slight damage;
– heavy damage;
– buildings collapsed or needing demolition.

Table VIIIA shows the percentages of cases observed during the survey for each category of buildings and damage. The discussion about this case focused on the problem of assessing an intensity value on the basis of this piece of information.

The participants assumed a coincidence between types G1, G2 and G3 with types A, B and C of MSK scale, even if some noticed that G1 coincides with A, but contains some elements of the B-type. In the same way, G2 includes both B- and C-type aspects. It seems that MSK types have been adapted to the characteristics of Friuli constructions, where, for example, brick houses are very few. But the original data are not available and since the source gives only the final result, it is impossible to modify the adopted typological classification.

As concerns the classification of damage, it seems that the compilers of the survey combined grades 1 and 2 (slight damage) and grades 4 and 5 (destruction and total damage) of the MSK scale. This choice increases the degree of uncertainty on the final estimate of the intensity. In fact, as an example, the distinction between damage 4 and 5 can modify the intensity by one degree.

The characterization of observed frequencies of damaged buildings in terms of the qualitative categories requested in the scale («few», «many» and «most») showed difficulties in the use of too rigidly separated percentages. Table VIIIB shows the result of a coherent use of MSK quantities. A slight difference in the estimate of percentages (from 5% to 15%) is sufficient to jump from «few» to «many» and thus from an intensity degree to the following upper one. The following step occurs at the 60% (from «many» to «most)» percentage. This means that, for example, in the locality of Maiano (table VIIIA), 100 buildings (17% = many) with «slight damage» have the same importance as 300 buildings (50% = many) collapsed or to be demolished.

Participants in the experiment underlined that, in several cases, a «few» buildings (2 or 3) may determine a high percentage values. As an example, in the case of Maiano, 4 buildings of G3-type are in percentage «many» buildings: this may suggest an intensity estimate of X or XI MSK-81. A number of participants suggested that, when the percentages are obtained taking into account only a small number of buildings they should be ignored. In fact, in these cases, few damaged buildings could reflect in unrealistic intensity estimates. However, this choice is only based on personal and uncontrolled evaluations.

This source could seem one of the more detailed, without problems in assessing intensity. However, the analysis of this case showed that the uncertainties are equal, or wider, than in

**Table VIII.** 1976 Friuli earthquake. A: data from the engineers survey; B: quantities of damaged buildings in terms of MSK-81 scale.

| Locality | Type structure | No. of buildings | No damage | % | Slight damage | % | Heavy damage | % | Collapsed or to demolish | % |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | | | | | | | | | | |
| | G1 | 2300 | 0 | 0 | 50 | 2 | 350 | 15 | 1900 | 83 |
| Gemona | G2 | 700 | 0 | 0 | 200 | 28 | 300 | 43 | 200 | 29 |
| | G3 | 30 | 4 | 13 | 15 | 50 | 3 | 10 | 8 | 27 |
| *Total* | | 3030 | 4 | 0 | 265 | 9 | 653 | 21 | 2108 | 70 |
| | G1 | 600 | 50 | 8 | 100 | 17 | 150 | 25 | 300 | 50 |
| Maiano | G2 | 950 | 150 | 16 | 300 | 32 | 250 | 26 | 250 | 26 |
| | G3 | 20 | 12 | 60 | 4 | 20 | 0 | 0 | 4 | 20 |
| *Total* | | 1570 | 212 | 14 | 404 | 26 | 400 | 25 | 554 | 35 |
| | G1 | 1000 | 0 | 0 | 50 | 5 | 50 | 5 | 900 | 90 |
| Buia | G2 | 1250 | 250 | 20 | 450 | 36 | 250 | 20 | 300 | 24 |
| | G3 | 10 | 0 | 0 | 5 | 50 | 4 | 40 | 1 | 10 |
| *Total* | | 2260 | 250 | 11 | 505 | 22 | 304 | 14 | 1201 | 53 |

| Locality | Type structure | No. of buildings | No damage | Slight damage | Heavy damage | Collapsed or to demolish |
|---|---|---|---|---|---|---|
| **B** | | | | | | |
| | A | 2300 | – | few | many | most |
| Gemona | B | 700 | – | many | many | many |
| | C | 30 | many | many | few | many |
| *Total* | | 3030 | | | | |
| | A | 600 | | many | many | many |
| Maiano | B | 950 | many | many | many | many |
| | C | 20 | most | many | – | many |
| *Total* | | 1570 | | | | |
| | A | 1000 | – | few | few | most |
| Buia | B | 1250 | many | many | many | many |
| | C | 10 | – | many | many | few |
| *Total* | | 2260 | | | | |

the case of older earthquakes less supported by documents. Even assuming that types G1, G2 and G3 coincide with types A, B and C, the uncertainty about damages qualification remains. As an example: do buildings «collapsed or to demolish» correspond to damage grades 4 or 5? Furthermore, as in 1873 case, the frequency distribution of damaged buildings does not correspond with any of the standard ones described in the scale.

### 3.4. *The case of the Government Palace of Fabriano (1741 earthquake)*

In this case, the source (ASCFa, 1741) was a very detailed survey of the damage which occurred at the government palace of Fabriano. The problem submitted to the participants was the best use of this information for intensity assessment.

Using this information, a group of participants assessed an intensity value, while another group only estimated the grade of damage. The participants of the first group suggested that damage like that described in the source is present in some degrees of the scale and thus, that it is possible to assess intensity on this basis. The final intensity estimates were very different. Using the MCS scale, intensity estimates range from V to IX. Using the MSK-81 scale, intensity estimates range from VI to VIII. The participant of the second group (the majority) stated that it is impossible to assess intensity using data referring to one building alone. They evaluated the damage degree, but the estimates were very uncertain ranging between grades 2 and 4.

This wide range of answers testifies the difficulties of seismologists, geologists and historians when they have to evaluate the information on damage. The contribution of some engineers to the experiment was very interesting. They were able to detect in the long historical description the most important structural elements that qualify the damage. On the basis of these evaluations the degree of damage was assessed as 4.

## 4. Conclusions

The experiment showed that the incompleteness of the available data is less important than the lack of procedures. In particular, intensity values supplied by the different operators on the basis of the same information span over ranges that in most cases are of the order of 2-3 degrees.

The discussion demonstrated that there are two principal phases in assessment of intensity where operator choices may result in different intensity values.

The first phase corresponds to the generation, from the original information, of a description comparable with the word picture proposed by the scale. In this phase, percentage estimates of damage for building typologies are settled. A crucial point is the availability of data about types of structures, total number of buildings and detailed damage description. In general, lacking this information, some hypotheses, based on personal experience or knowledge, have to be adopted. Furthermore, the experiment showed that, even if these data are available, the interpretation of the information in the framework of standard descriptions given in the scale is a difficult task which again requires a number of personal judgements in order to determine coded quantities («few», «many» and «most») and to classify damage information.

The second phase corresponds to the comparison between coded information and standard word pictures of the scales. The most important problem of this phase is that the distribution of damaged buildings obtained from earthquake records does not correspond (or very seldom corresponds) with that present in the scale. The experiment showed that, in many cases, the real distributions held elements present in different intensity degrees. In these cases the personal choices of the operator were decisive in assessing an intensity value.

The ambiguities involved in the intensity assessment can probably be reduced but not eliminated totally. However, the definition of standard procedures, in the form of a more or less formalized protocol, may reduce the scattering of possible intensity estimates supplied by different authors. In any case, the development of such a protocol may result in a more homogeneous intensities data base. The experiment carried out does not give definitive conclusions on this topic. Focusing on the problem and its first characterization can be only considered a very preliminary (but important) result. Many questions still have to be examined closely and an extension of experiments like this could approach the solution of some of them by the definition of general rules or protocols, accepted by the different operators for the assessment of intensity from documentary sources.

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