.

EERI INVITATIONAL WORKSHOP
AN ACTION PLAN TO DEVELOP EARTHQUAKE DAMAGE AND LOSS DATA PROTOCOLS
September 19th and 20th, 2002
Doubletree Hotel
Pasadena, California

AN OVERVIEW OF POST-EARTHQUAKE DAMAGE ASSESSMENT IN ITALY

A. Goretti, G. Di Pasquale
(National Seismic Survey, Department of Civil Protection, Italy)

SUMMARY

Since many years post-earthquake damage assessment has been in Italy one of the preliminary steps for the establishment of a proper reconstruction strategy. Although the main purpose of the damage assessment has always been the estimate of the direct economic loss, 1st level damage data and building type data have been collected extensively after each destructive and non destructive earthquake. This allows to perform statistical analysis on suffered damage and building type and to obtain correlation with seismic intensity, if the latter one is known. The paper describes old and recent Italian experiences in the field of damage assessment, highlighting resolved, but also not yet resolved problems, that have been encountered in assessing procedures, forms, tools, computerisation, validation, maintenance, and data dissemination.

INTRODUCTION

In Italy post-earthquake damage assessment has been performed since many centuries ago. After the 1570-1574 Ferrara Earthquake (IX MCS), the duke Estensi gave the architect Ligorio, belonging to the papal court, the responsability of the damage evaluation. His report concerned both public and private buildings and was so detailed that it has been possible to locate the mostly damaged buildings on a plan of the town. The report describes also many features of the local building techniques and includes a surprising list of vulnerability factors, as the “a sacco” masonry walls, the thrusting roofs, the offset floors. In that occasion no economic contribution was assigned by the Duke for the building reconstruction. The Pope reduced to 75% the taxes in order to facilitate the repair of the damaged churches (Guidoboni, 1987).
In the XVII-XX century in the middle Italy, the damage survey was mainly addressed to the financial contributions. In the Tuscany Grand Duchy, after the 1661 earthquake, the Grand Duke (Medici) required inspections in the stricken localities and an engineer was in charge of the damage assessment of the fortress. After the same earthquake the Papal State made an estimate of the overall economic loss in Romagna. The same happened after the 1688 earthquake when results of an expert’s report were communicated to the cardinal. After the 1781 earthquake the city of Faenza evaluated the economic loss, asking Rome for contribution. The post-earthquake reconstruction was made easier with loans, tax reductions and financial contribution for the poors (Guidoboni, 1987).
After the Italy unification, the Kingdom faced the 1887 Liguria earthquake (M=6.0, Io=IX[1]), the first seismic emergency of the new State, and the two catastrophic events of Messina, 1908 (M=7.2, Io=XI) and Fucino, 1915 (M=7.0, Io=XI). On that occasions, the damage survey was performed through expert’s reports made by the State (Civil) Engineers (National Seismic Survey, 2001).
After the II World War the Italian Republic faced the Belice 1968 (M=6.1, Io=X), Friuli 1976 (M=6.4, Io=IX-X), Irpinia 1980 (M=6.9, Io=IX-X) and Umbria-Marche ’97 (Ml=5.8, Io=IX-X) destructive earthquakes. Non destructive earthquakes, as Parma 1983 (M=4.8, Io=VI-VII), Abruzzo 1984 (M=5.6, Io=VIII) and Pollino 1998 (Ml=5.5, Io=VI-VII) earthquakes, have also been very important in assessing methodologies, procedures and protocols, (National Seismic Survey, 2001). During the last years a process of decentralisation occurred and the damage survey changed from a State to a Regional or Municipal duty, as after Parma 1983 earthquake. The decentralisation, together with the lack of a unitary trend, has been the reason why each earthquake has been managed differently, in terms of procedures, forms, inspectors, etc. The Umbria-Marche earthquake, the first time when the damage survey has been performed together with the usability survey, has been the beginning of an overall revision. Very recently, a standardised procedure for usability and damage assessment has been proposed by the Italian National Civil Protection and the National Seismic Survey (SSN) to all the Italian Regions and a training programme is started.

[1] Data of Magnitude M and epicentral intensity Io in MCS scale, up to 1992, are from (ING-GNDT-SGA-SSN, 1999). Magnitude M is obtained as weighted mean of macroseismic and instrumental values.

.

CLASSIFICATION OF DAMAGE COLLECTION

The classification of the damage collection can be done in different ways, according to the aim of the survey, to the involved discipline, to the time when data are collected, to the accuracy of the data (I, II or III level data[2]), to the amount of data to be collected, to the more or less perishable data. Many of the above item are strictly correlated and in the following three possible classifications will be presented, based on the aim of the data collection, on the involved discipline and on the time when data are collected. The latter one is more rational for establishing a proper strategy for data collection and it is very similar to a very recent Japanese classification (Building Research Institute, 2002).

Classification by the aim ("Why"):

- Short term usability assessment;
- Assessment of the overall economic loss or of the overall funding needed for reconstruction;
- Evaluation of the individual contributions;
- Social impact assessment;
- Prevention and emergency management;
- Scientific purposes.

Classification by involved disciplines:

- Geo-sciences: it mainly concerns strong ground motion data collection. Soil is permanent monitored by means of the Italian accelerogram network and data are collected at National Seismic Survey and are available on Internet. Mobile network is installed by SSN and by other institutions (as Universities or National Institute for Geophysics) after the event. In case of other institutions, they define the access to collected data.
- Structural Engineering, buildings: few buildings are permanently monitored by SSN and the recorded data are available when the event triggers the instruments. Extensive damage collection is performed after the event for reconstruction purposes. In this case buildings are temporarily monitored and there is high risk that some data perish. A similar extensive damage collection is performed on churches.
- Structural Engineering, other built systems: due to the moderate intensities of the Italian earthquakes, damage to lifelines or transportation systems is usually very limited. Data are not collected in a systematic way.
- Social sciences: homeless are recorded for each inspected buildings, while injured and fatalities are collected as aggregate data. Up to now no other data is systematically collected after the event.
- Economy (overall impact of the earthquake): no data is systematically collected after the event, mostly due to the long period of time and to the large geographical area that has to be monitored in order to collect significant data. Obviously records of the funding for the reconstruction are available.

The above classification gives an idea of what kind of data is available, but do not give insight to data collection, that is "when", "how many", "which accuracy". A different possible classification is then presented, based on when data are collected. What will be presented for buildings can be easily applied to a different sector.

Classification by "When" data are collected:

- Pre-event: The inventory for risk analysis or damage/emergency scenario is usually built up with I level accuracy. The survey is not directly related to damage collection, but sometimes the pre-event data base can provide the "denominator" if post-earthquake damage collection is performed only on the damaged buildings. Detailed III level data are collected on permanently monitored buildings. They could be also collected on pre-selected buildings, when showing a seismic behaviour reputed to be investigated.
- Post-event 2-3 days, 2-3 weeks: it is the time of the preliminary macroseismic intensity assessment (2-3 days) and of the reconnaissance survey (2-3 weeks). Data are not systematically collected. The Authors repute possible to collect some aggregate data in some fuzzy way, being useful to an immediate updating of the damage scenario.
- Post-event 3-60 days: During this period, the usability and damage assessment is performed. I level data are collected on a large number of buildings. As the inspections are performed on the citizen request, the collected data are generally biased.
- Post-event 30 days-some years. In order to get unbiased data from the usability and damage assessment, the completion of the survey is performed, with I level accuracy, in selected localities. III level accuracy data are collected on the permanent monitored buildings or on buildings with peculiar seismic behaviour.

The above classification shows that an high accuracy of the collected data (III level data) is not consistent with a huge number of inspected buildings. It could be interesting to check if the number of inspected buildings times the number of data per building is somehow constant when data are collected with different levels of accuracy (I, II or III level data). Moreover, similarly to other countries (Japan, Turkey), it appears that if the damage is to be collected

---

[2] Level I data are limited to information that can be collected trough a simple and quick visual inspection, level II data include additional elements on the structural characteristics, level III are data needed for an engineering evaluation.

.

on a huge number of buildings, the process should be performed under an “official” umbrella and possibly with a well recognised social value.

PRE-EVENT DAMAGE COLLECTION

In recent years a systematic typological, dimensional and functional data collection for residential and public built systems has been carried out in Southern Italy. The surveys have been funded by the National Civil Protection, as part of a seismic prediction program, and by the Ministry of Labor, as Social Workers have been used in the survey.
In the years 1996-97 all the public buildings (more than 40,000) in 1748 Municipalities in Southern Italy have been surveyed with a I and II level form by about 600 technicians (GNDT et al, 1999).
In 1996-1998 a sample of the private buildings has been surveyed in the same Regions (25,000 buildings, 1032 surveyors and tutors). The sample has been selected on the basis of information derived from Census[3] (GNDT et al, 2000).
In 1998–2000, the monumental buildings (1900 among churches and other buildings) located in different parks in Southern Italy and all the buildings located in 200 municipalities have been surveyed. In the latter case a quick inspection form, less detailed than the usual I level form, has been used (GNDT et al., 2001).
In the same years the survey of lifelines has been performed (water, sewage, electricity, gas, roads and railways). When data were not accessible to visual inspection, data were obtained by means of design drawings or by means of interviews with local technicians.
In the Catania Project (Faccioli and Pessina, 2000), funded by GNDT, 12,500 residential masonry buildings, 6,500 residential RC buildings and 700 public buildings have been surveyed with a quick inspection form.
Most of the data has been validated and computerised. Data related to lifelines have been only partially validated and computerised.
Due to a sudden collapse of few residential buildings, a recently proposed, but never approved, national law promotes the realisation, for every building in the whole country, of a booklet containing, among other items, also rough information on typology. It can be the start of a national inventory based on more technical data, as today it can be obtained only by means of the national Census data.

POST-EVENT DAMAGE AND USABILITY ASSESSMENT

The post-earthquake usability and damage evaluation is, at present, the major source of damage collection in Italy, as it is also in Turkey and Japan. Comparing different methodologies of damage collection, an important distinction should be made between: a) usability and b) damage survey. Post-earthquake usability assessment is commonly aimed to evaluate the possible short term use of the building (Building Research Institute, 2002; ATC-20, 1989, ATC20-2, 1995; Baggio et al, 2000; Goretti 2001; Dandoulaki et al, 1998). During the assessment, the buildings that can be safely used, in case of aftershocks, are settled, together with the emergency measures to be taken in order to reduce the risk for people.
On the other hand, many are the reasons why damage classification can be performed (Building Research Institute, 2002; Baggio et al, 2000). In Japan the aim of the damage assessment is to evaluate the long term use of the buildings. The result of the evaluation is a suggestion to the owner of the building concerning the repair, the retrofit or the demolition of the building. In Italy something similar happened in the past, but today the main purpose of the damage survey is to evaluate the usability and the overall amount of direct economic loss, useful to establish the financial contribution of the government for the reconstruction. The decision on long term use of the building is postponed to an engineering evaluation in the reconstruction process. In Greece damage survey is not performed, because financial contribution are established on the basis of the usability classification. In Turkey the damage classification is used to assign the financial contribution to each buildings. In the United States, to the writer’s knowledge, a systematic damage collection, in terms of suffered physical damage, is not performed by Federal or State agencies.
Strictly related to the aim of the damage survey is the way in which it is performed. In Italy not very detailed information are required and the data collection can be performed together with the usability survey. The advantage is to speed up the overall survey and hence the reconstruction process, as it is demonstrated (Kaas et al, 1987) that the time for the reconstruction process is very strictly related to the time for the emergency phase. The main drawback of this joint survey is to slow down the completion of the usability survey, although many of the data to be collected in the damage survey need to be taken into account in the usability survey. The slow-down is compensated by the fact that, in Italy, the usability and damage survey is performed in 2 steps, with a limited percentage of buildings requiring the second inspection (about 5%). In Greece and US the usability assessment is still performed in 2 steps, apart the engineering evaluation in US, but the number of buildings requiring the second inspection is very high. Main features of the usability and damage assessment in some countries all over the world are summarised in table 1 (Building Research Institute, 2002; ATC-20, 1989, ATC20-2, 1995; Baggio et al, 2000; Goretti 2001; Dandoulaki et al, 1998).

---

[3] Every 10 years a national census on population and dwellings is carried out in Italy by ISTAT (National Institute for Statistics). During this census also raw data on dwellings are recorded (floor area, age, number of floors in the building…..)

.

Table 1. Purpose of the usability and damage survey in Italy, Greece, Turkey, USA and Japan

	Usability survey	Steps	Damage survey	Survey
Italy	Short term use of the building	2	Establish overall amount of direct economic loss	Joint
Greece	Short term use of the building	2	Not performed	
Turkey	Short term use of the building	1	Establish financial contribution for each building	Distinct
USA	Short term use of the building	3	Not performed	
Japan	Short term use of the building	1	Suggestion for long term use of buildings	Distinct

It is worthwhile to mention other important "derived products" of the damage survey in Italy. They are: a) the macroseismic intensity assessment (Galli et al., 2001, Di Pasquale & Galli, 2001), b) the vulnerability assessment (Braga et al., 1982), c) the building classification (Zuccaro et al., 2000) and d) the site effects evaluation (Goretti and Dolce, 2002). It is also necessary to point out that the post-event usability and damage assessment is very different from the same assessment performed pre-event. This is particularly relevant in case of usability assessment, but it applies also to damage collection if a huge number of buildings is involved. Main features of the post-earthquake usability and damage evaluation, together with their consequences, are reported in table 2.

Table 2. Features and consequences for the post-earthquake usability and damage assessment

	Features	Consequences for usability assessment	Consequences for damage assessment
1	The seismic crisis is not ended	A new shock can occur. It must be taken into account in the usability evaluation. The assessment is valid until a new shock occurs. Reduced safety level should be accepted.	Cumulative damage is often recorded, while soil motion is recorded for each shock. A cumulative macroseismic felt intensity is usually assigned.
2	The number of inspections is very huge	Many inspectors are required, the inspection management should be effective and computerised. Procedures and forms should be prepared, and inspectors trained, before the event.	
3	Inspections should be completed as soon as possible in order to reduce the risk for inhabitants (usability assessment) and/or to speed up the reconstruction process (damage assessment).	The available time for the inspection is very limited. It is not possible to make a detailed dimensional and/or mechanical data collection and/or numerical analysis. Usability assessment must be based on visual inspection and on expert judgement, but also on interviews with local technicians to gather information on the local constructive practice.	The available time for the damage assessment is very limited. Collected data can only be I level data, mainly the observed physical damage, the building type and rough dimensional data.

All the previous items interact each others. For instance new shocks can increase the number of inspections to be performed, requiring more inspectors. The number of inspected buildings in recent Italian earthquakes is reported in table 3, where Io is the epicentral intensity and some data are to be considered approximate, being based on extrapolations.

Table 3. Inspected and unusable buildings in recent Italian seismic events

Event	Year	I_0 (MCS)	Inspections	Unusable buildings
Friuli	1976	X	>70,000 (§)	43,000 (*)
Irpinia	1980	X	38-250,000 (+)	120,000 (^)
Abruzzo	1984	VI-VII	51,000	N.A.
Marche	1997	IX-X	100,000	27,000 (27%)
Pollino	1998	VI-VII	18,000	4,100 (22%)

(§) Damage assessment
(*) Damaged or collapsed buildings
(+) Damage assessment on all the 38,000 buildings in 41 Municipalities, about 250,000 inspections on damaged buildings in all the Municipalities
(^) Estimated from 480,000 damaged or collapsed dwellings

The number of inspected buildings reported in table I can be compared with the 65,000 buildings inspected in Athens in 1999 (usability assessment) and the 46,000 buildings inspected in Kobe in 1985 (damage assessment). In passing note that after Kobe earthquake about 144,000 buildings collapsed or were heavily damaged. Hence the damage assessment has been performed on a selected set of damaged buildings. From table I, one can see that, after

.

destructive earthquakes, the number of buildings to be inspected can easily be in the range of 80-100,000, and could grow even more if a big city would be involved.
If a so huge amount of buildings has to be inspected before the event, the differences between pre-event and post-event survey obviously reduce. In fact procedures and forms used in the pre-event survey of public and private buildings in Southern Italy were similar to the ones used in the post-earthquake damage and usability assessment.

Before analysing the present usability and damage assessment methodology, it is interesting to summarise the past experiences, starting from the 1976 Friuli earthquake. In the following the overall procedures and forms will be compared, while in the next paragraph more emphasis will be devoted to building type and damage data collection.

After the Friuli earthquake in North-eastern Italy (May 6, 1976, Ms=6.5, about 900 fatalities, an important second shock in September) a comprehensive damage survey was carried out by the Region with the main purpose of assessing the economic loss and gather an initial indication on whether to repair or rebuilt the damaged buildings. The survey was carried out on the complete real estate stock in the epicentral zone and on its damaged portion in the other zones. The form used was entitled "Minutes for the damage assessment of residential or mixed use buildings" and consisted of five sheets:

- Sheet 1) general data relevant to the building (address, reference in map, use, number of stories), damage in term of repairability estimate (destroyed, not repairable, repairable totally or partially, repair not needed) and estimate of the repair cost as summary of sheets 3 and 4;
- Sheet 2) general data concerning each dwelling in the building (number of rooms, number of peoples, type of occupancy, owner or manager, …);
- Sheet 3) summary of the data used for the cost estimate (dimensions, volume, value of the building before the earthquake, repair cost) obtained collecting the data of sheets 4);
- Sheet 4) a sheet reporting the type of vertical and horizontal components, the type of finishing and plant, with the corresponding percentage of damage and the estimate of the repair cost;
- Sheet 5) Preliminary indication on the repair works.

As it can be seen, the inspector was responsible for the decision of the emergency measures, of the building repairability and of the cost estimate. No detailed data were collected for the destroyed buildings because in those cases rebuilding was the only possible option. Udine University has recently set up a database with the most relevant information recorded in the minutes, that were initially only on paper. The database, called FrED (Friuli Earthquake Damage Data) and containing about 76,000 damaged buildings, has been then transferred to SSN.
It is important to note that most of the damage assessment in epicentral zone was performed after the first shock, May '76. Other parts of the territory were surveyed after the second shock, September '76, so most of the macroseismic data cumulate the effects of the two shocks.

After the Irpinia earthquake in Southern Italy November 11, 1980, (Ms=6.9, about 3,000 fatalities) two different inspections were carried out:

- the first one, extended to the whole building stock (38,000 damaged and undamaged buildings) in 41 Municipalities, in order to have an unbiased sample. Felt intensities ranged from V to IX-X MCS. Main aim of the survey, carried out by expert teams with the cooperation of the military technicians, was the estimate of the overall economic loss;
- the second one was extended to all the damaged buildings in all the Municipalities stricken by the earthquake (more than 600). It was carried out by professionals managed by the Regions, with a form different from the previous one.

The form used in the first survey was very concise, it contained only one page. A field manual was added, aimed to explain how to evaluate the structural typology and the damage level, being the last one recorded separately for each structural and non structural component in a discrete, 8 levels, scale. About 38,000 records are available, most of them concerning masonry buildings.
The form used for the second survey was simpler. One part was devoted to the whole building and another to each dwelling or property in the building. The damage assessment, in this case, was essentially limited to an overall judgement on the repairability. The number of inspected building is very huge. In the small Basilicata Region were inspected about 228,000 dwellings in 72,000 buildings. Data were computerised on tapes by the Region and never updated. Today it is quite difficult to retrieve the data from tapes.

After the Abruzzo earthquake in Central Italy (May 7 and 11, 1984, Ms=5.8, 3 fatalities) the damage survey, managed by GNDT, was carried out on more than 240 municipalities. Aim of the survey was the usability assessment and the estimate of the repair cost. A revision of a previous form, set up by GNDT for the damage assessment after Parma 1983 earthquake, was used. The database contains about 51,000 inspected buildings, but only 15,000 can be referred to Municipalities completely surveyed. In the other municipalities the percentage of non inspected buildings is not negligible.

In 1985 a new form, specifically aimed to the quick safety evaluation, was proposed by GNDT (Gavarini, 1985). In the 1 page form, all the items to be considered in the usability assessment were listed and guidance was given to the decision pattern, trough a point system combining different penalties for each surveyed item. This interesting procedure was also implemented in an expert system, but had very few applications.

After the Umbria-Marche earthquake, Central Italy (September 26, 1997 Ms=5.9, 11 fatalities, aftershocks up to April 1998), the two involved Regions used different forms and the inspections were managed in different ways. However, in both the Regions a joint usability and damage survey was performed.
The Umbria Region had previously developed a 1 page form to record mainly the general features of the buildings (surface, stories, occupancy, maintenance before the earthquake,…), the damage (five damage levels for the main components) and the data required to estimate the repair cost (length and thickness of walls, proposed intervention and their extension,…). The form was not too clear, required too much time to be filled in each part and hence only few parts were filled. An overall evaluation of the repair cost was also required to the inspectors. As no building usability classification was included in the form, inspectors were required to write on the forms their judgement on the building safety. Every building was surveyed in the urban centres of the epicentral area and on request in non epicentral area or outside the urban centres in epicentral area.
The Marche Region did not have any predefined procedure or form. A preliminary form, developed by SSN and GNDT, was then used. The form was specifically conceived to give guidance in the safety assessment and it was much more easy to be filled than the one used in Umbria Region. Most of the information to be collected were in a predefined format, so only a mark was necessary to record the data. About 38,000 buildings were inspected and their data computerised by the Region during the emergency. Other inspections were carried out later by the technicians of Marche Region, leading to a total number of 48,000 records. The survey was on demand in both epicentral and non epicentral area, although it can be considered complete in some localities in epicentral area.
In both Regions public technicians inspected public buildings, professionals inspected residential houses and experts inspected churches and monumental buildings. In the latter case, representatives of the Ministry of Cultural Assets participated to the inspections. Inspectors were trained with a short course (1-2 hours). Survey of public buildings was managed by SSN and GNDT, survey of residential buildings was managed by the involved Regions.

The Marche ’97 form was subsequently updated on the basis of the lessons learnt: the pre-formatted fields for the surface, number of stories and occupancy were made more precise and the damage description was updated to explicit the total absence of damage. In 1998 the revised form was used for the joint usability and damage assessment (second experience in Italy) after the Pollino earthquake, Southern Italy (September, 9, 1998, Ml=5.5, 1 fatality). The survey was limited to the damaged buildings and the database contains about 20,000 records. Social Workers, previously employed for vulnerability assessment, were trained with a short course (1-2 hours) and used for the survey.

After Umbria-Marche 1997 and Pollino 1998 earthquakes, an action plan aimed to give uniformity to the damage and safety assessment has started. The final version of the form has been delivered in 2000. Nevertheless much more has to be done in order to clarify the aim of the survey, the responsibilities of the technicians and the relationship between damage survey and public funding for repair works. Furthermore all the Regions and the local Authorities involved in this activity should agree on the procedures and on the forms to be used, if these are to be, as it should be, the same for the whole country. SSN has organised, together with some Regions, a series of courses lasting about 5 days each, aimed to transfer the knowledge on these arguments. A long term goal of this action is to constitute a registry of about one thousand, well trained, public technicians, to be used in case of emergency. A computer code, to give guidance to the technicians in the damage and safety assessment (Masiani, 1999; Gavarini, 1999; Decanini, 1999), has been developed by SSN, together with the University of Rome, and it has been used for training purposes.

COLLECTED DATA

It has been shown that the large amount of buildings to be surveyed in a post-earthquake usability and damage assessment is the main reason why only I level accuracy data can be collected. Although the collected data cannot be used for an engineer assessment (II and III level), they can be statistically processed. Data concerning building identification are always necessary. In principle, when dealing with usability assessment, the only usability classification could be recorded and, similarly, when dealing with the direct economic loss, the only overall estimate of the repair cost could be recorded. However, in order to reduce the large subjectivity in usability assessment and in the repair cost estimate, an overall measure of damage or, better, the damage classification to different components, together with dimensional data, should be required. Building type is also useful when dealing with usability, repair cost or vulnerability functions, as it acts as a damage filter. Social data are finally useful to evaluate the earthquake impact. Data in the past, and at present, collected can be summarised as follows:

- Identification: Name, address, cadastral unit, photographs;
- Dimensional data: Mean surface, number of stories, height;
- Function: Property, function, percentage of use, number of dwellings and inhabitants;
- Building type: Materials, structural schemes, age of construction, maintenance, position;
- Soil condition: geomorphology, landslide;

.

- Building damage: damage levels and their extension in different components, overall measure of damage;
- Social data: homeless and families evacuated;
- Countermeasures; urgent barricades, already done or to be done;
- Quality of the inspection (complete, partial, from the exterior);
- Usability assessment;
- Notes

Data to be collected should be easily find out by visual inspection. In this sense, the age of the building is a non-robust information, as it can be obtained, in the emergency survey, only by means of interviews either with the owners or with the tenants of the building. Definition of the data to be collected should be unambiguous and self-explained, data should be maximally informative of past and future seismic performance, useful for present methodologies and possible also for next future methodologies, finally interchangeable between I, II and II level accuracy. An accurate training is essential to reduce ambiguity in data collection. Ambiguity in data users should be avoided making use of proper data explanation. Forms should be easy to be filled and codification of the data should permit immediate check of the recorded data. The Italian form, reported at the end of the paper, has been specifically studied to this aim. This has not always been done in the past, as we will summarise in the following for the special case of building type and damage data collection.

Up to the present form, in order to classify the building component, a selection among different descriptions of the component material was required. In the early time of Friuli '76 earthquake, 3 vertical structure descriptions (stone masonry, brick masonry and columns) and 2 horizontal structure descriptions (RC floors with RC beams and all other type) were included in the form. As some important features of the load bearing system were not specified in the form (shape of stones, layout, ..), different building behaviours are expected for the same component description, questioning the data process. In Irpinia '80, an improved classification, including 5 vertical and 4 horizontal structure descriptions, was proposed (Figure 1).

Vertical structures		**Horizontal structures**	
Irregular stones	1	Vaults	1
Hewn stones	2	Wooden	2
Brick or square blocks	3	Steel	3
RC	4	RC	4
Mixt	5		

Figure 1. Building type classification used in Irpinia '80 survey

Few years later, Abruzzo '84, the number of different descriptions of vertical structures was increased up to 8 different vertical types (3 for stone masonry, 3 for brick masonry, RC and Mixt), while keeping the same description used in Irpinia for the horizontal structures. This process culminated with the GNDT I level form (Figure 2)

Vertical structures	
"A sacco" masonry	A
"A sacco" masonry with strenghtenings	B
Hewn stone	C
Hewn stone with strenghtenings	D
Round stone masonry	E
Round stone masonry with strenghtenings	F
Tuff block masonry	G
Heavy concrete block masonry	H
Light concrete block masonry	I
Brick masonry	L
Hollow brick masonry	M
Plain concrete shear walls	N
RC shear walls	O
RC bare frames	P
Infilled RC frames (Weak infill)	Q
Infilled RC frames (Strong infill)	R
Steel	S
Mixt	T
Other	U

Horizontal structures	
Wooden	A
Wooden with iron ties	B
Steel beams and bricks	C
Steel beams and bricks with iron ties	D
RC	E
Vaults without iron ties	F
Vaults with iron ties	G
Vaults and horizontal floors	H
Vaults and horizontal floors with ties	I
Other	L

	Vertical	Stair	Horizontal	Number
281	B	3	C	2
285				
289				
293				
297				

Figure 2. Building type classification in GNDT I level form

Although the form has 18 different types of vertical structures and 9 different types of horizontal structures, often ambiguity, inaccuracy and systematic errors happened. The classification based on component description highlights approximations when one attempts to use it in a context that is different from the expected one, due to the impossibility of listing all the different component descriptions. Moreover components with similar descriptions, can, sometimes, exhibit different seismic performances. Inspectors were required to classify the components on the basis of their only visual features, without any judgement on their seismic performance. Also the codification used in GNDT I level form was very complicate, relying on 4 characters (Figure 2), related to the type of vertical structural, type of stairs, type of horizontal structural and number of floor with same classification. The code, as for example B3C2 in figure 2, does not provide at first sight the selected building type.
In order to solve the above problems, in the current form it is required to select the component performance, instead of the component description, involving, thus, the inspector expert judgement in the component classification. The form also considerably simplifies the compilation and the check, as it refers to broad building classes, characterised by similar vulnerability and seismic performance. The preliminary version of the form, used in Marche Region after Umbra-Marche '97 is reported in figure 3. It is possible to note that for vertical structures, classification was based on component performance, while for horizontal structures was still based on component description.

Vertical Structures / Horizontal structures		Masonry: Irregular layout or bad quality: Round stone without ties or beam ties	Masonry: Irregular layout or bad quality: Round stone with ties or beam ties	Masonry: Regular layout and good quality: Hewn stone or brick without ties or beam ties	Masonry: Regular layout and good quality: Hewn stone or brick with ties or beam ties	Masonry: Isolated columns	RC: Frame with soft story	RC: Frame without soft story	Steel	Uknown
1	Vaults	○	○	○	○	Yes				○
2	Wooden	○	○	○	○	○				○
3	Steel and vaults	○	○	○	○				○	○
4	Steel	○	○	○	○				○	○
5	RC	○	○	○	○	No	○	○	○	○
6	Uknown	○	○	○	○	○	○	○	○	○

Figure 3. Building type classification used in Marche Region after Umbria-Marche '97 earthquake

In the form, revised just in time for Pollino '98 earthquake (Figure 4), also the horizontal structure classification has been based on component performances. In addition the multiple answer option has been made more clear: when a circle is present a single answer is required, when a square is present, multiple answers are allowed. The RC and steel buildings classification has been improved making possible to mix, making use of the multiple answer option, RC shear walls, RC frames and steel frames. The RC and steel classification has probably to be further developed in order to include sources of weakness like short columns, abrupt changes of mass/stiffness/capacity, misalignments, maintenance, bad material quality and so on.

Vertical structures / Horizontal structures		Masonry: Uknown	Masonry: Irregular layout or bad quality (Round stones, ...): Without ties or beam ties	Masonry: Irregular layout or bad quality (Round stones, ...): With ties or beam ties	Masonry: Regular layout and good quality (Hewn stone, brick,..): Without ties or beam ties	Masonry: Regular layout and good quality (Hewn stone, brick,..): With ties or beam ties	Masonry: Isolated columns	Masonry: Mixt
1	Uknown	○	□	□	□	□	Yes	RC over masonry
2	Vaults without ties	□	□	□	□	□	○	○
3	Valut with ties	□	□	□	□	□		Masonry over RC
4	Flexible	□	□	□	□	□		○
5	Semi-rigid	□	□	□	□	□	No	In horizontal
6	Rigid	□	□	□	□	□	○	○

R.c. or steel structures	
R.c. frames	□
R.c. shear walls	□
Steel frames	□

REGULARITY		Irregular A	Regular B
1	Plan and elevation	○	○
2	Cladding distribution	○	○

Figure 4. Building type classification used after Pollino '98 earthquake

The last revision of the form dates back to may 2000, when retrofitted or strengthened buildings have been included in the classification. The form is enclosed at the end of this paper. In passing note that the form used in Umbria Region, after Umbria-Marche '97 earthquake, was more similar to Irpinia '80 and Abruzzo '84 (Figure 5).

Maintenance	good	medium	poor		good	medium	poor
VERTICAL STRUCTURES				HORIZONTAL STRUCTURES			
Stone	☐	☐	☐	Wooden	☐	☐	☐
Brick	☐	☐	☐	Steel	☐	☐	☐
Perforated brick	☐	☐	☐	RC	☐	☐	☐
Tuff	☐	☐	☐	Vaults	☐	☐	☐
RC	☐	☐	☐				
Mixt	☐	☐	☐				

Figure 5. Building type classification used in Umbria Region after Umbria-Marche '97 earthquake

Concerning damage classification, as the visual inspection is the only possible technique to assess post-earthquake damage on a huge number of buildings, procedures and forms usually require to record the observed damage. The severity of the observed damage is described by means of typical visible indicators of loss of performance, e.g. cracks, deflections, changes of geometry, separations of elements, instability of RC bars, spalling, etc. All the damage classification are articulated in degrees of severity and almost all use qualitative (type of damage) and quantitative (amplitude and extent) measures of damage.

In Friuli '76 earthquake the aim of the damage survey was to assess the repairability of buildings and to estimate the economic loss. The form contained a specific part related to the cost of countermeasures. Damage was not assessed quantitatively, but with the following descriptions:

Destroyed	☐			
Not repairable	☐			
Repairable:		Totally ☐	Partially ☐	Structural repair: yes ☐ no ☐
Repair not required	☐			

Figure 6. Friuli '76 damage classification

The lack of a clear relationship between the damage description and a quantitative damage scale is one of the major difficulties encountered today when re-analysing the collected data.
The original damage scale used in the Irpinia 1980 survey consists of eight levels and is reported in table 4. The damage states are identified by quantitative measures of different types of damage. Damage is to be assessed for vertical structures, horizontal structures, roof, external walls, partitions and stair. In the form there is a strict relationship between damage, usability and actions to repair or demolish the building. Today a so strict relationship is not introduced in the form, because damage applies to each building component, while repairability and usability often applies to the whole building. Moreover partial collapse can be so localised that demolition can not be required.

Table 4. Damage levels in the 1980 Irpinia earthquake survey.

Level	Severity	Usability	Long-term countermeasures
1	None	Usable	None
2	Negligible	Usable	Repair not urgent
3	Slight	Usable	To be repaired
4	Noticeable	Partially usable	Repairable
5	Heavy	Unusable	Repairable
6	Very heavy	Unusable	To be demolished
7	Partial collapse	Unusable	To be demolished
8	Destroyed	Unusable	

After the Abruzzo 1984 earthquake, damage survey was carried out using a 6 level scale. The damage is to be assessed for vertical structures, horizontal structures, roof, external walls, partitions, stair, projections and elevated objects. As in the case of Irpinia, information about damage extent were not collected explicitly because the extent of the damage was included in the degree of severity. In general the maximum observed damage is recorded for each component. As the damage classification is based on crack type (shear, flexural, ..) and failure modes (in plane, overturning, ..), a damage pattern categorisation is also required. It is reported in figure 7. In table 5 the description of the damage states in the masonry bearing walls is reported. It can be seen that quantitative measures (e.g. crack amplitude) used for damage classification depend upon the residual strength and upon the risk associated to the failure mode. For example a lower importance is attributed to flexural cracks near openings, often associated to local construction defects, or to non passing cracks, rather than to cracks associated to the complete separation of orthogonal walls or to crushing failures.

Table 5. Damage classification for masonry bearing walls used in the 1984 Abruzzo survey.

Level	Severity	Description
0	None	No visible damage
1	Slight	Cracks up to 1 mm
2	Relevant	Cracks up to 10 mm or up to 5 mm, when type 1-2-3 on more than 1/3 of the wall's surface.
3	Heavy	Cracks more than 10 mm wide or up to 10 mm, when type 1-2 between 1/3 and 2/3 of the wall's surface
4	Very heavy	Cracks type 1–8 up to 10 mm wide and on more than 2/3 of the wall's surface; leaning up to 50 mm with separation of floors; cracks type 1-8 40 mm wide on 1/3 of the wall's surface.
5	Destruction	

In the I level GNDT form, used after Parma '83 and S. Lucia '90 earthquake, the damage is articulated in six levels, from A to F. The inspectors have to identify the maximum damage, the damage with the highest extension together with its extension, the latter one expressed in 10 percentage classes. Damage assessment is performed at each floor and for the following building component: vertical structures, horizontal structures, stairs, partition and external walls. The damage description for each state is essentially the same of the Abruzzo '84 and is summarised in table 6 for the masonry bearing walls. A section of the form is devoted to the damage to non-structural elements, in order to take into account their influence on the economic loss and also on life-safety. The damage classification in the I level GNDT form is very precise, but relatively cumbersome to be assessed by non specialised personnel. Also the codification is not immediate as it requires for each floor with different damage a 4 character string as D4F2, being respectively the damage with the most extension, its extension, the most severe damage and the number of floor with the same damage classification.

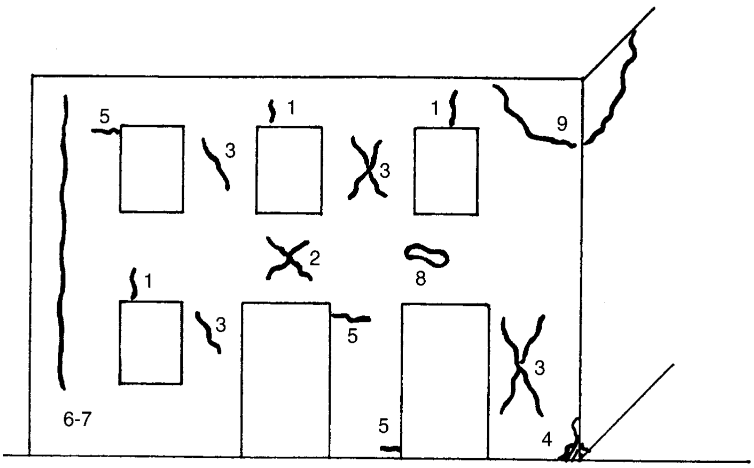

Figure 7: types of cracks in masonry bearing walls:
1) vertical cracks on openings; 2) diagonal cracks on parapets and on doors and windows lintels; 3) diagonal cracks on vertical walls between openings; 4) local masonry crushing with or without spalling; 5) horizontal flexural cracks on top or bottom of vertical walls between openings; 6) vertical cracks at wall intersections; 7) passing through vertical cracks at wall intersections; 8) spalling of material due to beam or floor pounding; 9) separation and expulsion of two corner walls.

Table 6. Masonry bearing walls damage classification (I level GNDT form).

Level	Severity	Description
A	None	No visible damage
B	Slight	Any crack up to 1 mm
C	Medium	Cracks up to 4 mm when types 1,5,6; up to 2 mm when types 2,3,7; up to 1 mm when types 4, 8 or 9.
D	Heavy	Cracks up to 10 mm when types 1,5,6; up to 5 mm when types 2,3,7; up to 1 mm when types 4, 8 or 9.
E	Very heavy	Cracks and damages higher than D.
F	Destruction	

The damage classification used in Marche Region after Umbria-Marche '97 earthquake is reported in the following figure. Main features of the classification are the simplicity, the immediate comprehension and the continuity with the past damage classifications. Damage levels have been condensed to three to further facilitate the compilation, but guaranteeing the possibility of back-chaining to the more detailed descriptions; the damage to structural elements has been separated from the damage to non structural elements (reported in another section of the form); the damage extent has been recorded in a simplified ‘fuzzy’ way, the preexisting damage has also been recorded. Damage classification is done simply marking the appropriate cell.

Level / Component		DAMAGE								
		D4-D5 Very heavy or collapse			**D2-D3 Medium or heavy**			**D0-D1 Null or slight**		
		> 2/3	1/3 - 2/3	< 1/3	> 2/3	1/3 - 2/3	< 1/3	> 2/3	1/3 - 2/3	< 1/3
		A	B	C	D	E	F	G	H	I
1	Vertical structures	○	○	○	○	○	○	○	○	○
2	Horizontal structures	○	○	○	○	○	○	○	○	○
3	Stairs	○	○	○	○	○	○	○	○	○
4	Pre-existing damage	○	○	○	○	○	○	○	○	○

Figure 8. Damage classification used in Marche Region after Umbria-Marche ’97 earthquake

As already said when dealing with building type classification, in Umbria Region a different form was used. The damage classification is reported in figure 9. Note the absence of null damage that questions when no data is recorded in the form, as it is impossible to tell if we are dealing with an undamaged building or with a non completed form. Moreover the building components are specialised only for masonry buildings. A preliminary analysis (Cherubini et al., 1998) showed the greater completeness of the form used in Marche Region. Completeness of building type was 98%, of damage to vertical structures 83-88%, of dimensional data 95-97%. In Umbria, analysing Nocera and Foligno Municipality (17,000 buildings), completeness of damage was 38% in Nocera and 18% in Foligno, of dimensional data was 81% in Nocera and 41% in Foligno, extension of repair works almost 35%. The comparison shows the better performance of a form containing multiple choice and multiple answer.

	Sligth	Medium	Heavy	Very heavy	Collapse
Masonry	□	□	□	□	□
Floors	□	□	□	□	□
Vaults	□	□	□	□	□
Roof	□	□	□	□	□
Stair	□	□	□	□	□
External walls	□	□	□	□	□
Foundation	□	□	□	□	□

Figure 9. Damage classification used in Umbria Region after Umbria-Marche ’97 earthquake.

In Pollino ’98, making use of the 1997 experience, the form used in Marche Region was improved. The null damage has been separated from the slight damage, as it was impossible to identify the undamaged buildings. Moreover the roof and unreinforced masonry infill walls, common in Italian RC buildings, have been included in the damageable building components, due to their importance in the estimate of the cost repair and life-safety.

Level Extension / Component		DAMAGE									
		D4-D5 Very heavy or collapse			**D2-D3 Medium or heavy**			**D1 Slight**			**D0 Null**
		> 2/3	1/3 - 2/3	< 1/3	> 2/3	1/3 - 2/3	< 1/3	> 2/3	1/3 - 2/3	< 1/3	
		A	B	C	D	E	F	G	H	I	L
1	Vertical structures	□	□	□	□	□	□	□	□	□	○
2	Horizontal structures	□	□	□	□	□	□	□	□	□	○
3	Stairs	□	□	□	□	□	□	□	□	□	○
4	Roof	□	□	□	□	□	□	□	□	□	○
5	URM Infill walls	□	□	□	□	□	□	□	□	□	○
6	Pre-existing damage	□	□	□	□	□	□	□	□	□	○

Figure 10. Damage classification in Pollino ’98

.

ACTUAL PROCEDURES, FORMS AND TOOLS

In Italy, the current methodology for the usability and damage survey has been established in the second half of 90's. A first version of the damage and usability assessment form was produced just before the Umbria-Marche 1997 earthquake and was subsequently upgraded. A complete procedure for the technical operations concerning all the damage survey after an earthquake was then proposed (SSN-GNDT, 1998) and integrated in the general framework of the emergency management system of the Civil Protection Department (*Augustus method*: function n. 9). The procedure was submitted to politicians and to local administrations, responsible for the emergency management. In this way we expect that a large consensus on procedures and forms will be reached, contributing to a standardised emergency management system. The last revision, together with the field manual, is very recent (Baggio et al., 2000). The 3 pages form is reported at the and of the paper.

In emergency, building inspections are performed on citizen demand, addressed to the Mayor of the Municipality. Once the different requests, related to the same building, have been grouped, requests are redirected to one of the Centres for the management of the damage survey (COM), usually located in epicentral area. Surveyors inspect the buildings and results are delivered each day at the management Centre, where are computerised. On this basis, the list of inspected buildings and buildings to be inspected is updated. In case of high risk and if suggested by the inspectors, the Mayor of the Municipality promulgate evacuation decrees or limited use decrees. Countermeasures suggested by the inspectors, when inserted in the Mayor decree, are compulsory. Usually the Fire Brigades are in charge of countermeasures if public safety is involved. No posting system is adopted. In the reconstruction process, as financial contributions for the building strengthening depend on damage level, damage is assessed again, and in more detail, by professionals. The inspection on demand and the lack of posting system are the main reasons for multiple inspections on the same building.

It is useful to compare procedures and forms for damage collection in other countries all over the world. In Japan inspections are performed only on multi-owner buildings. Buildings to be inspected are selected after a rapid post-earthquake building screening. Due to the citizen's privacy, the results of usability inspections are to be considered, usually, just a suggestion for the citizens. A posting system, reflecting the building usability classification, is adopted. Once completed the usability assessment, the damage assessment is performed. In Kobe damage assessment has been performed sending to each inspector team a plan of the city containing the buildings to be inspected. The inspectors, after completed the damage collections, delivered to Building Research Institute the 1 page forms, already computerised. After the damage classification, the repair, upgrade or demolishing of the damaged buildings is suggested to the owner. The suggestion, unless public safety is involved, in not compulsory for the building owners. In Greece, usability assessment is performed on all the buildings located in urban centres in epicentral area, while it is performed on citizen demand outside the urban centres or in non epicentral area. Also in US the usability assessment is performed on demand. In both US and Greece, a posting system is used. In Greece the 1 page usability form is the same for quick and detailed evaluation, while in US a 1 page form is used for quick and a 2 pages form for detailed evaluation. In Turkey, damage data are recorded on a single page line for each building. Main differences in procedures and forms among Italy, Greece, Japan and Italy are reported in table 7 (Goretti, 2001, Goretti 2002).

Table 7. Main differences in forms and procedures between Italy, Greece and Japan

	Usability and damage evaluation	Inspections	Results of usability inspection	Posting	Numb. of pages in the form
Italy	Simultaneous	On citizen demand	Compulsory if a Mayor decree is promulgated	No	1 form, 3 pages
Greece	Only Usability	Every building in epicentral area, on citizen demand in non epicentral area	Compulsory	Yes	1 page form, same form for quick and detailed inspection
US	Only usability	On citizen demand	Compulsory	Yes	1 page form for quick inspection, 2 page form for detailed inspection
Japan	At different time	On previously selected buildings	Compulsory only if public safety is involved	Yes	2 forms, 1 page each

Besides procedures and forms, tools are necessary to speed up the procedures and to give immediate information on the earthquake impact. Up till now, the following tools have been developed and delivered:

- Software for the management of the inspections (National Seismic Survey, 2002);
- Software for the data computerisation and reports (National Seismic Survey, 2002);
- Software for economic loss estimate from dimensional, damage and typological data (Di Pasquale et al., 1998).

The necessary upgrading of the form after recent earthquakes (Marche '97, Pollino '98, present version) forced to frequently revise the above tools, leading to obvious significant difficulties.

.

DATA COMPUTERISATION, VALIDATION, MAINTENANCE, ARCHIVING AND DISSEMINATION

In Italy, data computerisation is performed by the involved Regions (by Prefectures in Turkey, by inspectors in Japan) in (almost) real time. Computerisation is a crucial item when buildings are inspected on request, due to the fact that, in order to avoid multiple inspections on the same building, the selection of the buildings to be inspected should be done from an up-to-date building list. Major problems have been encountered due to the fact that, sometimes, computerisation slow down the survey process. The computerised inspected buildings do not coincide with the actual inspected buildings and multiple inspection on the same building can arise.
The computerisation id funded by the Regions or by the National Civil Protection as item necessary for a proper reconstruction. The software for the computerisation should be delivered, once tested, before the event. It should include an error routine and all kind of possible reports, as usable and/or unusable buildings, homeless, proposed emergency measures, in each municipality or aggregated, performed in one day or cumulative, etc. When the software has not been immediately available, different field names, variables type (text, logic, number or variant) and classifications appeared in the computerisation.

Validation is another important step of the process. Repeated inspections on the same buildings due to multiple shocks are expected, however very often erroneous repeated inspections to the same buildings arose due to buildings with more than one entrance, to buildings with more than one request, to non effective computerisation of the already inspected buildings, to inspections erroneously performed on dwellings instead of on buildings. Validation is performed by the involved Regions and funded by Regions or National Civil Protection, again as an item necessary for a proper reconstruction. Validation takes long time and it is usually performed with the aid of damage maps and making use, if possible, of the same inspectors used in the damage survey. In passing note that validation is required mainly because inspections are performed on request.

Once computerised and validated, data are acquired by National Seismic Survey, where are also maintained[4].
The updating of the data is not relevant for post-earthquake damage collected data. It is however relevant in case of pre-event survey, when dealing with the inventory. As in Italy pre-event survey are relatively recent (1996-1998), there is no need, today, to update the data. At the same time, a maintenance plan has not been established for the future. It is surely an high cost program and it is not clear which institution is in charge of and who will fund the updating of the collected data. Another non negligible item in data maintenance is the updating of the media where data are recorded, as new technologies require new media every few years.

Dissemination and access is the final issue of data collection. In order to codify the access to data, final users should be known (Universities, local governments, insurance companies, private companies) together with the purpose (Researches, emergency plans, risk and scenario assessment, outsourcing), the required data (name, localisation, damage levels, usability classification) and the level of aggregation of the data. Obviously privacy should be guaranteed avoiding that the single property could be detected, as damage and vulnerability data could also be used to lower the building value on the market. Up to now in Italy there has been very few application for the collected data. This does not mean that these data are not be used, as in fact they are by SSN and by some Universities. The absence of applications is mainly due to the lack of attention to these themes. The insurance market is not well developed and many jurisdictions, mainly in high risk Southern Italy, are so overwhelmed by ordinary emergencies that are not able to be active in prevention and emergency management. Consequently, also very few private company are involved in scenario and risk analysis.

CONCLUSION

The high value of the post-earthquake data, as real data, opposed to laboratory data, has always been well recognised. Post-earthquake data are invaluable in establishing plausible prevention plans (risk assessment, seismic codes, action plans for risk reduction) and a reasonable emergency management (seismic scenarios for emergency plans, repair cost estimate). A proper data management, (collection, maintenance, diffusion) is also important to augment the value of the data, while preserving the privacy. From the above consideration it appears that an action plan aimed to post-earthquake damage collection should be funded, planned and maintained before the event.
In this framework, an outline of the Italian experiences in the field of damage assessment has been presented. Resolved, but also not yet resolved problems, encountered in assessing procedures, forms, tools, computerisation, validation, maintenance, and data dissemination, have been highlighted.
Although Italy has a long history in post-earthquake damage evaluation, systematic damage data collection started only in the '70. Since then, different forms and procedures has been used. The major source of damage data has always been the post-earthquake usability and damage survey. The overall damage in the municipality, taken into account in the macroseismic assessment and at present not recorded, can be another source of data, useful for real time scenario updating.

---

[4] Very recently the Department of Civil Protection has been reorganized, with SSN as an Office. It is not clear, at the moment, if the centralization of databases will remain or not.

.

The recent Umbria-Marche ’97 earthquake gave rise to an action plan aimed to uniform usability and damage assessment procedures and forms, to train the inspector teams and to provide tools to manage inspections and to computerise and process the collected data.
The high number of buildings to be inspected in post-earthquake usability and damage evaluation allow only for I level data collection. Nevertheless collected data all over the world vary considerably, owing to the different purposes of the damage assessment. Major drawbacks in Italy come from the survey on demand, as it causes biased samples and multiple inspections on the same buildings. Collected data are later computerised with predefined tools and then validated. In order to avoid some of the above difficulties, it is proposed to perform the survey on every building in epicentral area and on request on non epicentral area. Moreover, the use of GIS systems and pre-event database will speed up the damage assessment, the computerisation and the validation of the data.
After the emergency phase, during the reconstruction process, the completion of the damage data should be made, in order to reduce the bias of the samples. At the same time the detailed damage collection (III level) on a reduced set of buildings should be performed.
The reliability of the data come from unambiguous terms in the form and from well trained inspectors. Forms with multiple choice and multiple answers seems to perform better. As an example the answer ”none” should always be present in the form and not deduced from the fact that no answer is marked. Similarly the component performance should be preferred to the component description. The accuracy of the collected data is related to the accuracy of the inspection, and, to this end, buildings should not be inspected by the only building exterior.

REFERENCES

ATC 20, 1989, *Procedures for post-earthquake safety evaluation of buildings.*

ATC 20-2, 1995, *Addendum to ATC 20 post-earthquake building safety evaluation procedures*.

Baggio C., Bernardini A., Colozza R., Corazza L., Della Bella M., Di Pasquale G., Dolce M., Goretti A., Martinelli A., Orsini G., Papa F. & Zuccaro G., 2000, *Field Manual for the I Level Post-earthquake Damage, Usability and Emergency Measures Form*, National Seismic Survey & National Group for Defence against Earthquakes, (In Italian).

Braga F., Dolce M. & Liberatore D., 1982, “A Statistical Study on Damaged Buildings and an Ensuing Review of the M.S.K.-76 Scale”. *7th ECEE-Athens*.

Building Research Institute, 2002, “Guideline for Damage Survey Methods of Earthquake Disaster Related with Buildings and Houses”.

Cherubini, G. Cifani , L. Corazza, G. Di Pasquale, A. Martinelli, G. Orsini & C. Spuri (1998), “The Performance of the Damage Survey and Safety Evaluation Form”, *Proc. International Workshop on Measures of Seismic Damage to Masonry Buildings*, Monselice, Italy, June 25-27, 1998, Balkema, Rotterdam.

Dandoulaki M., Panoutsopoulou M. & Ioannides K., 1998, “An Overview of Post-earthquake Building Inspection Practices in Greece and the Introduction of a Rapid Building Usability Evaluation Procedure after the 1996 Konitsa Earthquake”, *Proc. XI European Conference on Earthquake Engineering*, Balkema, Rotterdam.

Decanini L., 1999, “Seismic Scenario, Vulnerability and Damage in Usability Assessment”, Course on *“The Damage Survey and Post-Earthquake Usability Evaluation”*, National Seismic Survey, University of Rome, Catania Municipality, Catania 16 November 1999 (In Italian).

Di Pasquale G. & Galli P., 2001, “The Damage in the Area West to Gualdo Tadino after the 3 April 1998 Earthquake”, *Ingegneria Sismica*, 18, 3-12 (In Italian).

Di Pasquale G., Orsini G. & Serra C., 1998, “Assessment of the Economic Loss from the DPC–GNDT–SSN Safety Evaluation Forms”, *Proc. International Workshop on Measures of Seismic Damage to Masonry Buildings*, Monselice, Italy, June 25-27, 1998, Balkema, Rotterdam.

Faccioli E. & Pessina V. (Eds), 2000, *The Catania Project. Earthquake Damage Scenarios for a High Risk Area in the Mediterranean*, GNDT, Roma.

Galli P., Molin D., Camassi R. & Castelli V., 2001, “ The 9 September 1998 Earthquake Related to the Historical Seismicity of the Calabro-lucano Area. Seismotectonic Implications”, *Il Quaternario*, 14, 31-40 (In Italian).

Gavarini C., 1985, “Post-earthquake Building Usability: a Proposal, *L'Industria Italiana del Cemento*, n. 6, 1985, (In Italian).

Gavarini, C., 1999, “An Outline of Emergency Surveys: from Damage to Usability”, Course on *“The Damage Survey and Post-Earthquake Usability Evaluation”*, National Seismic Survey, University of Rome, Catania Municipality, Catania 16 November 1999 (In Italian).

GNDT, Ministry of Labour, Civil Protection, 1999, *Vulnerability survey of public, strategic and special buildings in Abruzzo, Basilicata, Calabria, Campania, Molise and Sicily Regions*, Graphicpress srl, L’Aquila (In Italian).

GNDT, Ministry of Labour, Civil Protection, 2000, *Vulnerability survey of part of residential buildings in Abruzzo, Basilicata, Calabria, Campania, Molise and Sicily Regions*, CUP srl, Rome (In Italian).

GNDT, Ministry of Labour, Civil Protection, 2001, *Survey of Monumental Buildings Located in National or Regional Natural Parks*, Okprint, Rome (In Italian).

Goretti A., 2001, "Post-earthquake Building Usability Assessment". *Technical Report SSN/RT/01/03*, (In Italian).

.

Goretti A., 2002, “Post-earthquake Usability and Damage Evaluation of Reinforced Concrete Buildings Designed Not According to Modern Seismic Codes”, *JSPS Short Term Fellowship Final Report* & *Technical Report SSN/RT/02/01*, March.

Goretti A. & Dolce M., 2002, “Site Effects Evaluation from Surveyed Typological and Damage Data”, *XII European Conference on Earthquake Engineering*, 9-13 September, London.

Guidoboni E., 1987, “Earthquakes in Ferrarese Area”, *Storia Illustrata di Ferrara*, Vol. 40, AIEP Editor, (In Italian).

ING-GNDT-SGA-SSN, 1999, “Parametric Catalogue for Italian Earthquakes”, Editrice Compositori, Bologna (In Italian).

Kaas J.E., Kates R.W. & Bowden M.J., 1977, *Reconstruction Following Disaster*, MIT Press, Cambridge, London.

National Seismic Survey & GNDT, 1998, *Handbook for the COM Management*, Civil Protection Department, Rome (In Italian).

National Seismic Survey, 2001, *Travel in Seismic Areas. Liguria, Basso Piemonte, Toscana, Emilia Romagna*, Rome (In Italian).

National Seismic Survey, 2002, *S.E.T. Software to Manage the Inspections and the Data Collection in Post-earthquake Emergency*, CD–ROM, Rome (In Italian).

Masiani R., 1999, “SEAT (Expert System on Earthquake Usability)”, Course on *“The Damage Survey and Post-Earthquake Usability Evaluation”*, National Seismic Survey, University of Rome, Catania Municipality, Catania 16 November 1999 (In Italian).

Zuccaro G., Papa F. & Baratta A., 2000, "Revision of the National Map of Residential Building Seismic Vulnerability", in A. Bernardini (Editor), *La Vulnerabilità degli Edifici: Valutazione a Scala Nazionale della Vulnerabilità Sismica degli Edifici Ordinari*, CNR-GNDT, Rome (In Italian).

Presidenza del Consiglio dei Ministri
DIPARTIMENTO DEI SERVIZI TECNICI NAZIONALI

Consiglio Nazionale delle Ricerche
GRUPPO NAZIONALE PER LA DIFESA DAI TERREMOTI

Presidenza del Consiglio dei Ministri
DIPARTIMENTO NAZIONALE DELLA PROTEZIONE CIVILE

1° LEVEL FORM FOR POST-EARTHQUAKE DAMAGE AND USABILITY ASSESSMENT AND EMERGENCY MEASURES IN RESIDENTIAL BUILDINGS

(AeDES 05/2000) **Request code** |__|__|__|__|__|__|__|__|__|__|

SECTION 1 Building identification

Province: ____________________

Municipality: ____________________

Locality: ____________________

Address

1 ❍ Street |__|__|__|__|__|__|__|__|__|__|__|__|__|
2 ❍ Road
3 ❍ Alley |__|__|__|__|__|__|__|__|__|__|__|__|__|
4 ❍ Square Number |__|__|__|__|

5 ❍ Other ____________________
(Indicare: contrada, località, traversa, salita, etc.)

INSPECTION DATA

Surveyor |__|__|__| day month year Form n.|__|__|__|__|
Date |__|__|__|__|__|__|

1.1 IDENTIFICATIVO EDIFICIO

Istat Reg.	Istat Prov.	Istat Municip.	Aggregate num.	Building num.
|__|__|__|	|__|__|__|	|__|__|__|	|__|__|__|__|__|	|__|__|__|

Istat Locality code |__|__|__|__| Tipo carta ____________
Istat Census code |__|__|__| N° carta |__|__|__|__|

Land Register Foglio |__|__|__| Allegato |__|__|
Particelle |__|__|__|__| |__|__|__|__| |__|__|__|__| |__|__|__|__|

Building location 1 ❍ Isolated 2 ❍ Internal 3 ❍ End 4 ❍ Corner .

Building name or owner name |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__| ***Code Use*** |S |__|__|

Sketch of structural aggregate and building location

SECTION 2 Building description

Metrical data				*Age*	*Use*			
Total number of stories	***Average interstory height*** [m]	***Average floor area*** [m²]		***Costruction age and strengthening*** [max 2]	***Use***	***Numb.of units in use***	***Utilisation in percentage***	***Occupants*** (100 / 10 / 1)
❍ 1 ❍ 9	1 ❍ ≤ 2.50	A ❍ ≤ 50	I ❍ 400 ÷500	1 ❑ ≤ 1919	A ❑ Residential	|__|__|		0 0 0
❍ 2 ❍ 10	2 ❍ 2.50÷3.50	B ❍ 50 ÷ 70	L ❍ 500 ÷650	2 ❑ 19 ÷ 45	B ❑ Production	|__|__|	A ❍ > 65%	1 1 1
❍ 3 ❍ 11	3 ❍ 3.50÷5.0	C ❍ 70 ÷ 100	M ❍ 650 ÷900	3 ❑ 46 ÷ 61	C ❑ Business	|__|__|	B ❍ 30÷65%	2 2 2
❍ 4 ❍ 12	4 ❍ > 5.0	D ❍ 100 ÷ 130	N ❍ 900 ÷1200	4 ❑ 62 ÷ 71	D ❑ Offices	|__|__|	C ❍ < 30%	3 3 3
❍ 5 ❍ >12		E ❍ 130 ÷ 170	O ❍ 1200 ÷1600	5 ❑ 72 ÷ 81	E ❑ Public	|__|__|	D ❍ Non in use	4 4 4
❍ 6	***Undergr. stories***	F ❍ 170 ÷ 230	P ❍ 1600 ÷2200	6 ❑ 82 ÷ 91	F ❑ Storage	|__|__|	E ❍ In constr.	5 5 5
❍ 7	A ❍ 0 C ❍ 2	G ❍ 230 ÷ 300	Q ❍ 2200 ÷3000	7 ❑ 92 ÷ 01	G ❑ Strategic	|__|__|	F ❍ Unfinished	6 6 6
❍ 8	B ❍ 1 D ❍ ≥3	H ❍ 300÷ 400	R ❍ > 3000	8 ❑ ≥ 2002	H ❑ Turistic	|__|__|	G ❍ Abandon	7 7 7 / 8 8 8 / 9 9 9

Ownership A ❍ Public B ❍ Private

Istat Province |__|__|__| Istat Municip. |__|__|__| Surveyor N°|__|__| Form N°|__|__|__|__|__|__| Date |__|__|__|__|__|__|

SECTION 3 Building Type (multi-answer; max 2.)

Horizontal Structures \ Vertical structures	Unknown	Masonry buildings: Irregular layout or bad quality (stones, pebble,..) – Without ties or tie beams	Irregular layout or bad quality – With ties or tie beams	Regular layout and good quality (Hwen stones, bricks,..) – Without ties or tie beams	Regular layout and good quality – With ties or tie beams	Isolated columns	Mixt	Strengthened
	A	B	C	D	E	F	G	H
1 Unknown	○	□	□	□	□	SI	□	□
2 Vaults without ties	□	□	□	□	□	○	G1	H1
3 Vaults with ties	□	□	□	□	□		□	□
4 Flexible floors	□	□	□	□	□	NO	G2	H2
5 Semirigid floors	□	□	□	□	□	○	□	□
6 Rigid floors	□	□	□	□	□		G3	H3

R.c. or steel structures

R.c. frames	□
R.c. shear walls	□
Steel frames	□

REGULARITY	Irregular	Regular
	A	B
1 Plan and elevation	○	○
2 Cladding distribution	○	○

Roofs

1 ○ Heavy and thrusting
2 ○ Heavy and non thrusting
3 ○ Light and thrusting
4 ○ Light and non thrusting

SECTION 4 Damage to Structural Elements and existing emergency measures

Structural component - Pre-existing damage \ Damage level and extension	DAMAGE (1): D4-D5 Very Heavy > 2/3	D4-D5 1/3 - 2/3	D4-D5 < 1/3	D2-D3 Severe > 2/3	D2-D3 1/3 - 2/3	D2-D3 < 1/3	D1 Light > 2/3	D1 1/3 - 2/3	D1 < 1/3	Null	EXISTING EMERGENCY MEASURES: None	Removal	Ties	Repair	Propping	Barrier or protection
	A	B	C	D	E	F	G	H	I	L	A	B	C	D	E	F
1 Vertical structures	□	□	□	□	□	□	□	□	□	○	○	□	□	□	□	□
2 Horizontal structures	□	□	□	□	□	□	□	□	□	○	○	□	□	□	□	□
3 Stairs	□	□	□	□	□	□	□	□	□	○	○	□	□	□	□	□
4 Roofs	□	□	□	□	□	□	□	□	□	○	○	□	□	□	□	□
5 Claddings and partitions	□	□	□	□	□	□	□	□	□	○	○	□		□	□	□
6 Pre-existing damage	□	□	□	□	□	□	□	□	□	○						

(1) - The damage extension must be filled only if the corresponding damage level is present in the building.

SECTION 5 Damage to Non-structural Elements and existing emergency measures

Damage	PRESENT	EXISTING EMERGENCY MEASURES: None	Removal	Propping	Repair	No entry	Barrier or protection
	A	B	C	D	E	F	G
1 Falling of plaster, coverings, false-ceilings	○	○	□	□	□	□	□
2 Falling of tiles, chimneys...	○	○	□	□	□	□	□
3 Falling of ledges, parapets, canopies	○	○	□	□	□	□	□
4 Falling of other internal or external objects	○	○	□	□	□	□	□
5 Damage to hydraulic or sewage plant	○	○			□	□	□
6 Damage to electric or gas plant	○	○			□	□	□

SECTION 6 Falling objects from other buildings and existing emergency measures

Cause	Risk on: Building	Entry road	Lateral roads	Existing emergency measures: No entry	Barriers or passing protection
	A	B	C	D	E
1 Object falling from adjacent buildings	□	□	□	□	□
2 Lifelines damage	□	□	□	□	□

SECTION 7 Soil and Foundation

SITE MORPHOLOGY	DAMAGE (present or possible): □ Slopes □ Foundation Soil
1 ○ Top 2 ○ High slope 3 ○ Mild slope 4 ○ Plain	A ○ Absent B ○ Produced by eqk. C ○ Worsened D ○ Preexistent

Istat Province |__|__|__| Istat Municip. |__|__|__| Surveyor N°|__|__| Form N°|__|__|__|__|__|__| Date |__|__|__|__|__|__|

SECTION 8 Usability assessment

Risk assessment

RISK	STRUCTUAL (Sect. 3 e 4)	NONSTRUCTURAL (Sect. 5)	EXTERNAL (sect. 6)	GEOTECHNICAL (sect. 7)
SMALL	❍	❍	❍	❍
SMALL AFTER MEASURES	❍	❍	❍	❍
HIGH	❍	❍	❍	❍

Building Classification

A	USABLE	❍
B	USABLE AFTER EMERGENCY MEASURES	❍
C	PARTIALLY UNUSABLE (1)	❍
D	TEMPORARELY UNUABLE (to be re-inspected)	❍
E	UNUSABLE	❍
F	UNUSABLE DUE TO EXTERNAL RISK (1)	❍

(1) Restrictions on building use must be clearly reported in the notes when building is classified as B or C. Falling hazard when building is classified as F.

Inspection accuracy

1 ❍ From the outside only
2 ❍ Partial
3 ❍ Complete (> 2/3)
4 ❍ Not inspected: because of
a ❍ Inspection refused
b ❍ Ruins
c ❍ Demolished
d ❍ Owner not present
e ❍ Other ……………………………..
………………………..………. ………………………………………………………...

Suggested emergency measures, limited extension(*) or wide extension (**)

*	**	Suggested emergency measures		*	**	Suggested emergency measures
1 ❐	❐	Ties	7	❐	❐	Removal of ledges, parapets, canopies
2 ❐	❐	Repair of light damage to partitions or claddings	8	❐	❐	Removal of other kind of falling objects
3 ❐	❐	Repair of light damage to the roofs	9	❐	❐	Barriers or passing protection
4 ❐	❐	Stair propping	10	❐	❐	Repair of plants
5 ❐	❐	Removal of plaster, coverings or false ceilings	11	❐	❐	
6 ❐	❐	Removal of tiles, chimneys	12	❐	❐	

Unusable dwellings, families and people to be evacuated

Unusable dwellings |__|__| Families to be evacuated |__|__| People to be evacuated |__|__|__|

SECTION 9 Notes

On the damage, emergency measures, usability, etc.

Item	Notes

Signs of the surveyors

_______________________ _______________________