TECHNICAL REPORT

Community Civil Protection Mechanism Assessment Mission

Italy Earthquake 2009

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Monitoring and Information Centre (MIC)
DG Environment
European Commission
B-1049 Brussels
Tel. +32 2 29 85060
Fax. +32 2 29 90314
http://www.ec.europa.eu/environment/civil

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Note:
CCPM - Community Civil Protection Mechanism
MIC - Monitoring and Information Centre
JRC - Joint Research Centre

TECHNICAL REPORT

1. GENERAL SITUATION

1.1 Community Civil Protection Mechanism

The main role of the Community Civil Protection Mechanism is to facilitate co-operation in civil protection assistance interventions in the event of major emergencies which may require urgent response actions. This applies also to situations where there may be an imminent threat of such major emergencies. It is therefore a tool that enhances Community co-operation in civil protection matters and was established by the Council Decision of 23 October 2001.

In accordance with the principle of subsidiarity, CPM goal is to provide added-value to European civil protection assistance by making support available upon request of the affected country. This may arise if the affected country's disaster preparedness is not sufficient to provide an adequate response in terms of available resources. By pooling the civil protection capabilities of the participating states, the Community Mechanism can ensure even better protection primarily of people, but also of the natural and cultural environment as well as property. Since its creation, the Mechanism has provided civil protection assistance in a variety of natural and man-made disasters.

On 10 April 2009, the Italian Civil Protection authority requested through the Community Civil Protection Mechanism the presence of technical experts (structural engineering / civil engineering / earthquake engineering) to support the Italian staff in assessing the stability of buildings.

1.2 Background and Situation Analysis

The following information was directly obtained during the mission briefings. Data and figures are those reported by the experts and national authorities.

1.2.1 About the earthquake

The 5.8-local magnitude earthquake hit L'Aquila, capital of the Abruzzo region, at 3:33, A.M. local time, on 6 April 2009. According to Dr. Paolo Marsan of the Italian Civil Protection, the affected area (Map 1) is a narrow valley, surrounded on both sides by 2000 m high limestone mountains and having an alluvium deposit of up to 500 m. The depth of the hypocenter was about 8 km, therefore the earthquake was rather shallow, being 20 km a typical focal depth in the Apennines region. The maximum intensity was estimated at 8.5 MCS.

The event corresponded to a normal faulting mechanism, and the fault is visible on surface in various locations, for instance in the village of Paganica.
Many affected villages were on locations with soft alluvium deposits of 300 m. This was for instance the case of the villages of Onna and Paganica, which were almost destroyed by the earthquake, and in which accelerations up to 0.6g were recorded (the maximum recorded peak ground acceleration was 0.68g).

In the city of L'Aquila, the geological conditions are quite different, because the town is built on a stiff conglomerate layer resting on the alluvial soft soil of the valley. This corresponded to complex local amplifications, and a peak ground acceleration of 0.35g was recorded just below the conglomerate layer.

The main earthquake was preceded by an intense seismic activity, and was followed by many aftershocks (Map 2), still taking place during the time of the mission. The epicentre of the second main shock took place South-East of the one of the main event, whereas a third one took place North of it. The continuous occurrence of aftershocks, along with the presence of individuals and organizations pretending they had been able to predict time and location of the event, and raising alarms about the next occurrences, contributed to maintaining a very high level of concern in the population.

1.2.2 Emergency management

According to Prof. Mauro Dolce, Director General responsible for Evaluation, Prevention and Mitigation of the Seismic Risks, Recovery and Rebuilding Activities, the action of the civil protection was immediate and effective. The Operational Committee was activated in Rome immediately after the event, and an advanced team was deployed to the site two hours later. The level of the emergency was immediately set as "National" (as opposed to lower levels such as "Municipal", to be coordinated by the mayor, "Provincial" or "Regional", to be coordinated by the local authorities). The coordination activities had to cope with the fact that the Prefecture building had collapsed, Figure 1, (even though the collapse was due to the failure of an adjacent building); however, they were facilitated by the availability of a large gymnasium of an army school, in which the DICOMAC, the central coordination structure, was established. DICOMAC is coordinating the seven (recently increased to eight) COMs, joint coordination centres, in which the different operational structures are grouped on a functional basis, Figure 13.

Civil protection, as a direct service of the Presidency of the Council of Ministers, had a role of coordination, rather than providing direct assistance. The coordination is applied to the impressive number of individuals directly working for the emergency, up to 12,000 people including volunteers. The system for civil protection is strongly based on volunteering, a spirit which is strongly felt in Italy, that goes back to the tradition of "Misericordia", established in the 12th century, and relies on the possibility of having up to 30,000 volunteers ready in few days.

1.2.3 Assessment of the usability of the buildings

Two days after the event, before the end of the first emergency phase, the assessment of the usability of buildings was initiated. The situation corresponded to an estimate of about 50,000 affected buildings (including public buildings, offices and factories), with the aim of bringing as many people as possible back to their places as soon as possible.
For this reason it was decided to start from the less damaged areas (the threshold being set at 6.5 MCS) rather than the most affected, such as the historical centre of L'Aquila for instance, also because of the continuing concern of aftershocks. This priority was decided because of the large number of people involved: 50,000 people were assisted by the civil protection (about 35,000 living in tents, 30,000 in hotels made available on the coast, the rest living in

second homes or sleeping in their cars; however, it had been estimated that up to 100,000 people were sleeping out of their homes.

The assessment was based on visual inspection and relied on assessment forms which were produced by the Italian Civil Protection and shared with the European earthquake engineering community in the framework of the European project LessLoss.
The instructions regarding the use of the forms were provided by Mr. Agostino Goretti of the Italian civil protection. It was made clear that the assessment was only relevant to short-term usability, i.e. to exclude the possibility of collapse in case of aftershocks, assuming an intensity generally not greater than the one of the main event; however, considering that a larger intensity might be experienced by a building distant from the epicentral area, due to the possibility of migration of the epicentre. The assessment had to include the evaluation of the nonstructural elements, such as partitions and infill walls, and the risk originating from nearby buildings also had to be evaluated.

The assessment activity was conducted by 500-600 experts in teams of 2-3 people, each team assessing 4-10 buildings per day, so that 1000-1500 buildings are assessed every day. The aim is to conclude the assessment of the 50,000 buildings within two months.
The results of the assessment (updated at the end of the mission) corresponded to 55% of the assessed buildings being classified as usable, 15% usable with short-term measures, 20% not usable, the rest requiring further study to be classified. It has to be recalled that the assessment procedure has been so far limited to areas which suffered relatively low damage. Once the areas affected by high damage are included (e.g., the historical centre of L'Aquila), the percentage of not usable buildings might increase significantly. Updated results for the assessment activity are being posted in the website of the Italian civil protection, www.protezionecivile.it.

The situation is rather different regarding monument buildings (churches, castles, palaces). For those, the procedure is directly handled by the Ministry for Culture, under mandate to the universities of Genoa, Padua and Milan. Dedicated forms have been developed for churches and for palaces. Experts from those universities operate directly in doing the assessment, in close collaboration with the authorities for the preservation of the cultural and historical heritage and the fire-fighters.
The activity of the fire-fighters is mandatory, because the access to historical buildings ends up being particularly dangerous, and also because the outcome of the assessment quite often results into the definition of possible short-term or sheltering measures, which are finally enforced by the fire-fighters.

Fire-fighters were not available for such activities during the first phase of the emergency due to their impressive commitments. According to Dr. Clara Modesto, engineer of the Italian fire-fighters, they have been on site with a more or less constant presence of 2300 individuals, and they have been providing 32,000 rescue operations. Besides collaborating in the assessment of normal buildings with 100 experts, fire-fighters are now collaborating in the assessment of the monument buildings and, more importantly, they are putting in place systems for sheltering, by means of their specialized units in timber construction and their SAF units, specialized in operating with helicopters and high cranes, Figure 2.

The number of affected heritage buildings is impressive. It has been said that in the historical centre of L'Aquila there are 99 churches. This might not be correct; however, it is possibly true that all churches in downtown L'Aquila are severely damaged.

The situation is made worse by the facts that the whole centre of L'Aquila has been evacuated, most of the buildings are likely to collapse even after small aftershocks, and the narrow roads are full of debris, Figure 3. Accessing the individual buildings is per se a major problem. Removal of the debris from the roads might make the access easier; however, this is not possible in most cases, due to the need to identify and collect the stone blocks which felt from monuments and palaces in view of their possible reconstruction, Figure 4. Fire-fighters have so far been active in measures having high impact for preserving the identity of the places and of the communities, such as retrieving from debris the relics of saints, removing bells from leaning campaniles, Figure 5, removing paintings and art crafts. An intervention which might work as an example is the sheltering of the cathedral of Onna, Figure 6, a village of which very little else remains.

2. COMMUNITY CP MECHANISM ASSESSMENT MISSION

2.1 Community CP Mechanism assessment team

After the request from the Italian Civil Protection authorities, a team of eight European experts on structural assessment was deployed to the area affected by the L'Aquila earthquake.

The objectives of the mission were defined as follows:

1. Supporting the Italian civil protection authorities by providing technical expertise in the assessment of stability of buildings;
2. Assessing further needs, anticipating problems and suggesting solutions with regard to buildings damaged by the earthquake;
3. Cooperating with Italian Civil Protection and other technical teams operating in the affected areas; and
4. Liaising with the MIC by maintaining close contact with the MIC liaison officer and the MIC headquarters in view of identifying further opportunities for cooperation.

The team was composed of the following members:

- Alex H. Barbat (ES)
- Alfredo Campos Costa (PT)
- Evridiki Koulori (EL)
- Paolo Negro (EC - JRC)
- Stefan Tahn (DE)
- Fabio Taucer (EC - JRC)
- Philippe Taupiac (FR)
- Polona Weiss (SI)
- Antonín Petr (EC - MIC)

Mr. Antonín Petr acted as the MIC liaison officer. Dr. Paolo Negro was charged with the duty of coordinating the reporting activities from the technical side.

2.2 Summary of activities

The team received accurate preliminary briefings by the MIC and the Italian Civil Protection authorities.

To obtain a sufficiently accurate overview of the situation and of the extent of damage, the group, assisted by the Italian fire-fighters, made a one-day reconnaissance tour of the affected area, complemented by a helicopter tour, made possible by the Italian Navy.

The bulk of the work conducted by the team consisted in participating in the operations for the assessment of the damaged buildings, for both the purposes of providing extra assistance and to get a practical insight about the way the operations were conducted. The Italian Civil Protection provided a briefing about the method and the associated forms to be filled for each building to be inspected. The CCPM team members either formed groups of two people (in such case, by putting together one person able to speak Italian with another member, due to the need to interact with the owners of the buildings), or joined existing assessment groups as individuals.

These activities were conducted for three days, and took place in the residential areas of L'Aquila as well as in Sulmona, a town which was much less affected by the earthquake and in which the assessment activities had just been activated.

Another day was dedicated to the assessment of the damage in churches and cultural heritage buildings. For such structures, different assessment forms were used, and the procedure was carried out by groups of volunteer experts in structural engineering along with representatives of the local authorities for the preservation of arts and cultural heritage, with the assistance of the fire-fighters. Two members of the CCPM team joined each assessment team.

Contacts were continuously maintained with the Italian Civil Protection authorities through the International Relations Unit of the civil protection. The liaison member, with the assistance of the CCPM team member in charge of coordinating the technical report, provided every day the MIC with a report of the activities. Reporting was much facilitated by the system developed by the Institute for Protection and Security of the Citizen of the Joint Research Centre at Ispra as a part of the Institutional Action Crisis Monitoring Response Technologies, which allowed information and photos to be continuously uploaded toward the crisis room along with GPS information of the itinerary.

At the end of the mission, a formal de-briefing meeting was held with the Italian Civil Protection (Prof. Mauro Dolce, Director General responsible for Evaluation, Prevention and Mitigation of the Seismic Risks, Recovery and Rebuilding Activities, Dr. Agostino Miozzo, Director General of Voluntary Service and Institutional Relations and Dr. Mauro Chilante from the Institute for the Technologies of Construction of the National Council for Research), in which both the CCPM team members and the Italian Civil Protection exchanged ideas and expressed their views about the effectiveness of the cooperation.

The team had several high-level contacts during the activity, including a meeting with the President of the Council of the Ministers, Mr. Silvio Berlusconi, Figure 14, and with the *prefetto* Mr. Francesco Paolo Tronca.

2.3 Observations of the mission

In spite of the fact that the team operated in areas with relatively low damage, the number of damaged buildings and the level of damage were impressive.

Technical elements such as quality of construction, lack of maintenance and absence of steel ties have contributed to the failure or poor behaviour of old masonry buildings, Figure 7, and this does not come as a surprise. On the other hand, in many cases, old masonry buildings in which steel ties had been placed apparently did not suffer any damage, Figure 8.

Lack of maintenance was found to be the reason for the decision of evacuating many old masonry buildings. In the case of Sulmona, a town only slightly affected by the earthquake, whether the damage was due to the earthquake or was pre-existing turned out to be seriously questionable.

A large number of old reinforced concrete buildings, possibly built before seismic provision were enforced, suffered extensive damage and some of them collapsed. Old construction practice and materials (smooth steel rebars, possibly low quality concrete, insufficient confinement) contributed to the poor seismic performance, Figure 9.

What was found to be particularly surprising was the extent of damage in recent, or even new, buildings. As a rule, the reinforced concrete frames did not suffer much damage, in most cases with a width of cracks compatible with minor or no yielding of rebars, whereas the damage to infill walls and partitions was almost total. Apparently, this is due to the fact that limits in deformations were enforced by the Italian regulations only after 1996; however, the same kind of damage was found in buildings which had been just completed, Figure 10 therefore there are possibly lessons to be learnt about the importance of stiffness in the design of ductile structures.

Insufficient seismic separation joints, or even the absence of them, were found to be the reason for the failure of many otherwise well conceived buildings, Figure 11.

The few observed industrial buildings, mainly precast reinforced concrete structures, Figure 12, behaved very well. In the few cases in which damage was reported, it related to excessive displacements in the joints, and was already being repaired.

Using the forms for the assessment of the buildings was found to be an efficient way to decide about their short-term usability. The assessment forms turned out to be reasonably easy to understand and complete, even though they turned out to be much more accurate for the case of masonry structures than for the case of reinforced concrete ones. However, the accuracy of the resulting assessment was felt to be sufficient in both cases. The forms proved to be easy to understand and complete, even taking into account that some members of the CCPM team had not been exposed to those forms before. In collaborating with the existing assessment teams, the members of which in some cases only had a broad expertise in structural assessment, it was possible to conclude that the forms are perfectly adequate to the need of quickly and reliably assessing any kind of building structure.

The experience of the CCPM team with the assessment of monument buildings has been limited to churches. In such cases, the assessment forms were found to be very efficient, leading to the identification of all mechanisms and to the evaluation of the damage associated

to each of them. No experience was gained as for the forms for the assessment of palaces, which were said to be more cumbersome by the colleagues with whom the CCPM team operated.

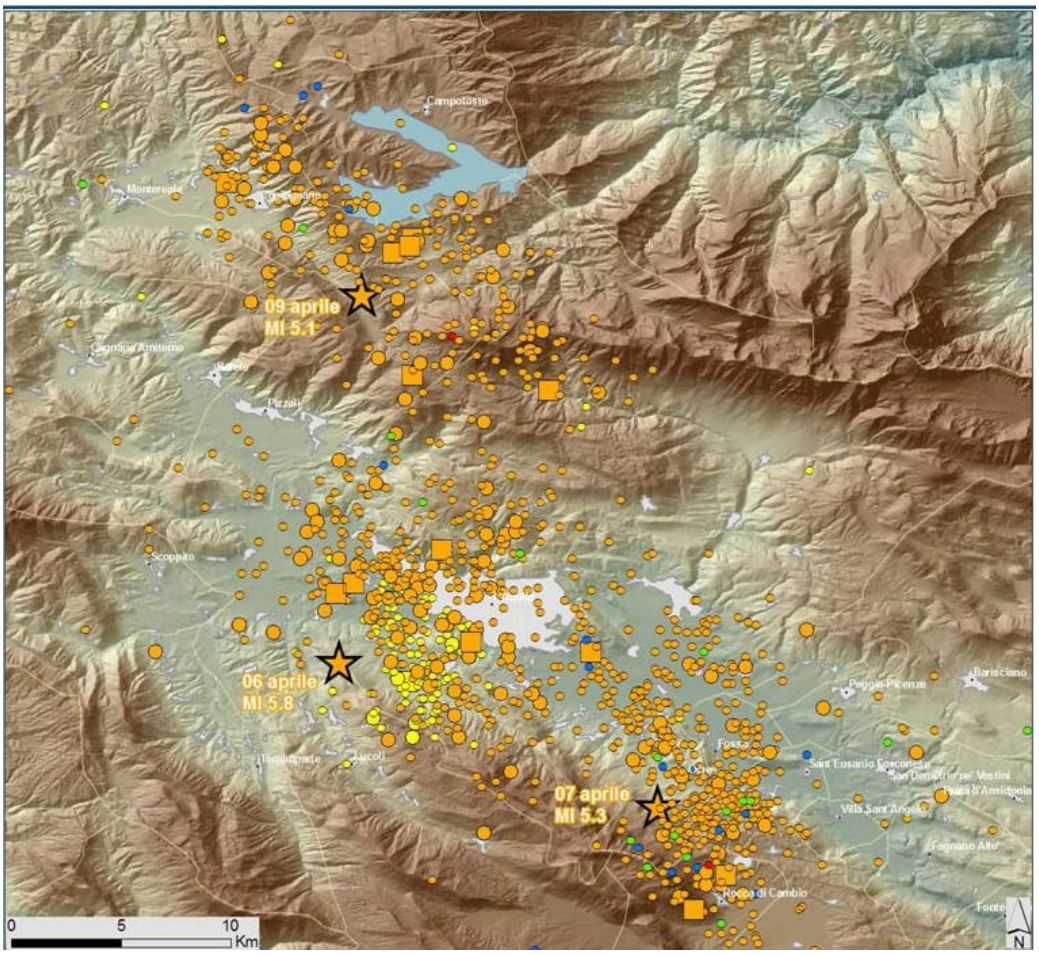
Finally, the practical procedure for forming and instructing the teams, for distributing the tasks and for collecting the forms was found to be very efficient.

3. CONCLUSIONS AND RECOMMENDATIONS

- The team was impressed by the quality and efficiency of the logistics put in place and of the procedure applied for the assessment of buildings.
- The method, based on visual inspection and use of dedicated assessment forms, is simple, relatively fast, and reliable.
- The forms should possibly be made more complete for the case of reinforced concrete buildings. This would allow much more information to be collected; however, in their present status the forms remain sufficiently accurate for the short-term assessment of the buildings.
- Since the forms are based on the visual inspection of the damage, their use in areas slightly affected by the earthquake might be questionable.
- The instructions given to the individuals doing the assessment are sufficient to allow for the technical work to be performed by them. However; it was noticed that some teams do involve the owners of the inspected buildings in the assessment work to a possibly too large extent, whereas others refuse to provide any information to them. Clear instructions about how to interact with the owners should also be given to the teams.
- In talking to the owners of the buildings being inspected, it turned out that many people were biased in their decision to eventually go back to their homes by the rumours about possible earthquakes which were spread by identified or unidentified individuals and organizations. It is of paramount importance that civil protection sets up a unit with the necessary expertise in psychology and communication to limit the impact of those actions, which might jeopardize the result of the best assessment procedures.
- Based on this experience (it has to be highlighted that this was the first time that non-Italian experts were directly involved in the post-earthquake assessment of buildings), it seems that a common European language does exist for the assessment of buildings affected by the earthquake.
- The experience of the CCPM team demonstrated that sharing capabilities and expertise of the civil protection organizations of different European states is possible. Support from other European states should become the rule during the assessment phase following the emergencies, whenever there is a need for it. Rules defining the required qualification and the liability framework for the experts should possibly be defined at the level of the Union. Efforts towards a possible harmonization of the forms to be used in the assessment of buildings at European level should be made.

4. MAPS AND FIGURES

Map1: Google Map of the affected area



Map2: Locations of the aftershocks *(Source: INGV Italy)*

Figure 1: Damage to the Prefecture building.

Figure 2: SAF nucleus of Italian fire-fighters in action

Figure 3: Street in the historical centre of L'Aquila

Figure 4: Stone pieces falling from monuments and needing collection

Figure 5: Successful recovery of the bells from the campanile

Figure 6: Sheltering of the Cathedral of Onna

Figure 7: Collapse of old masonry buildings in Onna

Figure 8: Historical centre of L'Aquila: apparent good performance of old masonry building strengthened with ties

Figure 9: Collapse of old reinforced concrete building

Figure 10: Very recent building which suffered extensive nonstructural damage

Figure 11: Consequences of the lack of seismic separation joint

Figure 12: Industrial building

Figure 13: DICOMAC

Figure 14: Italian Prime Minister Mr. Silvio Berlusconi meets the MIC team