

April 2009 Earthquake in Central Italy: initial considerations about reconstruction costs e procedure

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Legislation regulating earthquake reconstruction work in Italy

Italy is a country frequently struck by earthquakes of medium intensity. In April 2009, an earthquake swarm that had been carrying on for several months reached its climax with an earthquake measuring 5.9 on the Richter scale. A heavily built-up area of Central Italy was hit with damage to a large number of buildings and very many people affected. In particular, the city of L'Aquila, situated close to the epicentre, is the regional capital with an important old town centre and plenty of industry. The earthquake caused 308 deaths, 1600 injured and damage to more than 40,000 buildings. In May 2012, a new seismic event, comprising 3 tremors of magnitude greater than 5, struck the Emilia-Romagna Region in the north of Italy, causing 17 deaths, hundreds of injured and more than 17,000 homeless. Reconstruction following the 2009 earthquake and regulated by Act No. 77/2009 was handled in a much different way to previous earthquakes. Actions to reconstruct business premises, residential housing, public and monumental buildings were soon implemented with around 22,000 damage repair projects financed in the three years since the earthquake, of which 10,000 have already been completed and 12,000 are in progress. The paper provides some figures regarding the amounts actually spent, with particular reference to the grants received to repair ordinary buildings. A critical analysis has also been made of the statutory solutions adopted in order to finance damage repair operations, highlighting their strengths and weaknesses and the possible scope for improvement.

Keywords: earthquake, seismic vulnerability, buildings, damage, reconstruction costs

1. Introduction

Following a seismic event with very serious consequences, such as that which occurred in Central Italy on 6th April 2009, in a scenario where only a very small number of properties are insured, the starting point for handling the reconstruction is the drafting of specific legislation regulating the damage repair work. The seismic event in question, culminating with an earthquake of magnitude Mw 6.3, struck a heavily built-up area, causing 308 deaths and more than 1600 injured, whilst making more than 35,000 buildings uninhabitable (data from survey using AeDES forms last updated February 2011). In addition to housing, the

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categories of buildings damaged include business premises, public and monumental buildings. Act 77-2009 specifies the manner in which compensation is paid for earthquake damage, this being based on financing the detail drawings for the repair work. The procedure is completely different to those adopted following previous earthquakes in Italy where funding would be granted according to certain parameters such as the building's surface area, degree of damage and vulnerability; such legislation may be considered prescriptive and called for several steps: 1) determination of the extent of damage to each property and consequent allocation of a specific class; 2) calculation of the maximum permitted grant according to the building's allocated damage class, certain seismic vulnerability parameters and a few other characteristics such as the presence of primary residences or businesses, etc.; 3) preparation of the detail drawings for the repair work and execution. On the other hand, the legislation implemented following the 2009 earthquake may be considered performance-based since it does not allocate the building a preassigned classification based on the maximum permissible grant and does not require the execution of specific types of work, but simply specifies the level of seismic safety to be achieved, this being decided by the result of the building safety assessment following a brief survey immediately after the earthquake. Act 77/2009 also calls for immediate preparation of detail drawings for the repair work that will be used to check that the estimate is fair and the work proposed is necessary. The implementation of this legislation has allowed repairs to properties with light damage (safety rating "B" or "C") to begin very quickly, but various shortcomings have been noted when dealing with more seriously damaged buildings (safety rating "E"). For the reasons just explained, in order to deal with the reconstruction of the buildings damaged by the earthquake that struck Northern Italy in May 2012 (Mw 6.0, 17 deaths, around 17,000 homeless), the legislator has introduced some notable changes to the regulatory framework specified by Act 77/2009, preferring an approach in many respects similar to that of previous legislation.

2. The reconstruction costs of the 2009 earthquake

For the first time in Italy, government grants to repair damage were awarded on the basis of the results of the safety assessment carried out straight after the earthquake and the detail drawings for the repair work. On the contrary, after previous earthquakes, grants were calculated according to parameter-based costs and preliminary damage and vulnerability assessments carried out by designers following safety assessments. Details follow of the various steps specified by the above-mentioned Act 77/2009 in order to qualify for a grant to repair damaged property.

2.1 Surveying damage and safety in the post-earthquake emergency

Surveying damage and assessing safety are priority tasks in the post-earthquake emergency. Such activities allow identification of the structures and areas that could represent a risk to the population and those that may continue to be used, thus reducing inconvenience to citizens and possible further damage. In 1997, a joint working group of the National Earthquake Protection Group and National Earthquake Service comprising distinguished members of the Italian civil service and scientific community designed a form for surveying the damage, authorising emergency repairs and assessing the safety of

ordinary buildings after the earthquake. This form had already been tested in areas of the Marche Region struck by an earthquake on 26th September 1997. Known as the "AeDES form", it was subsequently included in the Joint Operations Centre (COM) Technical Management Manual approved in November 1998 by the National Commission for the Forecast and Prevention of Major Risks and following improvements it was also used after later earthquakes in various parts of Italy. The form is split into 9 sections; the first 3 provide unambiguous identification of the building in question and include a description and details of construction type, the others contain a description of the damage and any emergency work already carried out or needed to prevent further damage and in conclusion allocate a safety rating. The form enables completion of a quick survey and initial cataloguing of building stock since it contains details of building type and dimensions. The manual in question defines the concept of safety (and therefore usability) as follows: *"The safety assessment in a post-earthquake emergency is an expeditious, provisional assessment - meaning that it is based on an expert opinion and completed quickly by means of visual inspection and collection of readily-accessible information - that aims to establish whether, in the presence of a seismic event, the buildings that have previously been struck by the earthquake can continue to be used, providing a reasonable level of protection of human life."*

There are 6 usability ratings, of which the most important, also used for allocating grants, are safety rating "A" (building usable, no significant damage, low risk, the entire building may be used without putting the life of its occupants at risk), classes "B" (building temporarily uninhabitable, localised damage, medium risk, simply requires certain emergency repairs in order to enable use of the entire building without risk for its occupants) and "C" (building partly uninhabitable, localised damage, medium risk, the condition of certain areas of the building is such as to place the occupants at very high risk) and class "E" (building uninhabitable, serious damage, high risk, no part of the building may be used even after completion of emergency repairs).

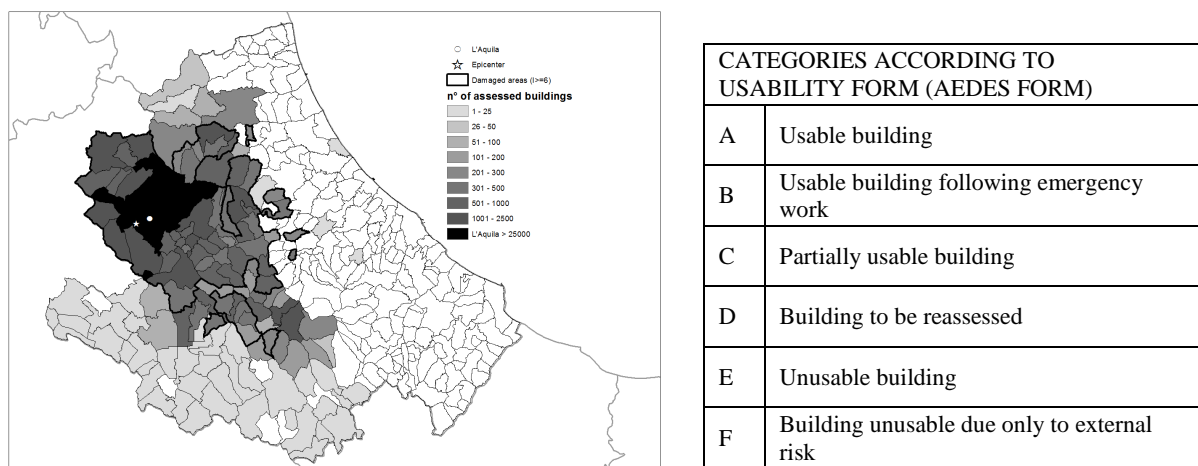


Figure 1: No. of AeDES forms completed per municipality and brief description of usability ratings

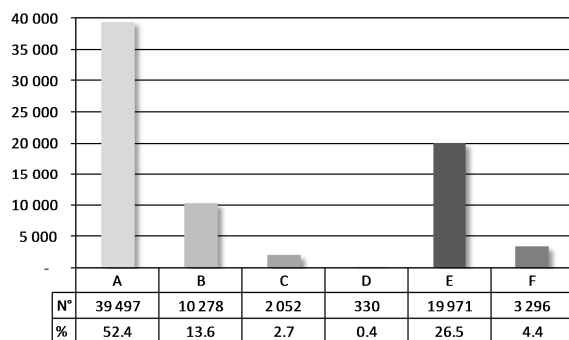


Figure 2: results of the post-earthquake damage and safety assessment: all municipalities

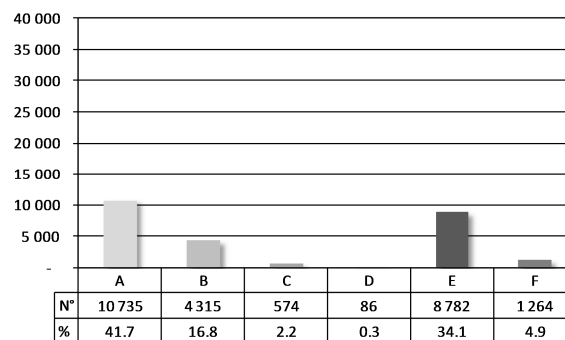


Figure 3: results of the post-earthquake damage and safety assessment: city of L'Aquila

2.2 Allocation of repair grants

As happened following previous earthquakes in Italy, Act 77/2009 provides for grants to cover the cost of repairs and seismic retrofitting of buildings damaged by the 2009 earthquake. Unlike previous earthquakes, the Act in question does not set limits to the amount of the grant, there being a specific reference to the possibility of "*covering the entire cost of repairs, reconstruction or purchasing of similar accommodation*"; furthermore, with prevention in mind, the Act also provides for the allocation of additional funds for damaged buildings for the "maximum reduction of seismic risk".

Act 77/2009 also calls for the appointment of a Government Commissioner and the enactment of Prime Ministerial Ordinances in order to implement its provisions. Following the Prime Ministerial Ordinances, various decrees and circulars were enacted by the above-mentioned Government Commissioner. The use of a further two levels of legislation in addition to the original Act (Prime Ministerial Ordinances and Government Commissioner Decrees) has led to delays and created a great deal of confusion, thus creating an unnecessarily complicated and chaotic regulatory framework. Act 74/2012 regulating post-earthquake reconstruction in Emilia Romagna does away with the intermediate step of the Prime Ministerial Ordinances, thus restoring the regulatory approach adopted prior to the 2009 earthquake.

Taking their lead from the provisions of said Act, the subsequent implementing measures have split the grant into two categories: one for damage repairs, covering as much as the full cost, and the other for seismic risk reduction with a maximum lump-sum payment calculated according to the outcome of the building's safety assessment.

Another important difference compared to the legislation adopted following previous seismic events concerns the necessity to prepare detail drawings for the repair work as a first step, including a written estimate from the building contractor, before the grant application can be considered.

The grant application, complete with detail drawings for the repair work and bill of quantities, is approved by the local council (Commune) assisted by a support unit that carries out checks according to preset criteria. After the preliminary checks are complete, the Commune approves the grant for repair work. Payment is made from funds previously allocated in accordance with progress reports. While the work is in progress or following completion, the Commune performs random checks in order to verify the correct execution of the work.

In the case of previous earthquakes, the safety assessment was followed by an intermediate stage that allowed the building to be classified in a certain grant category according to the amount of damage suffered and verification of a number of preset vulnerability parameters. The grant was therefore first calculated according to certain parameters on the basis of the category allocated to the property and then paid off gradually as the work progressed. So in the past, there was no need for approval of the entire set of detail drawings for the repair work, its compliance with certain parameters specified by the emergency legislation was deemed sufficient. In most cases, a minimal amount of seismic retrofitting of the property was requested, but the overall project was subject to less specific checks.

Unlike in the case of previous earthquakes, the legislator's choices with regard to the post-earthquake reconstruction of 2009 have allowed immediate financing and execution of the work, eliminating the intermediate step of building classification that had been necessary in the past. It has also allowed more careful control to be exercised over projects and the grants given, since checks are carried out, in particular on the detail drawings, in order to confirm the fairness of the proposed costs and scope of work. Other than in an initial settling-in period lasting just a few weeks, the mechanism has worked rather well as regards the funding of repair work for lightly-damaged buildings (with usability rating B or C). The table below shows the number of grant applications received, the number approved and the amount allocated in million euro.

Table 4: number of processed requests

Usability categories	Number of requests	Funding requests	Amount financed (M€)
A	7 615	7 615	70.23
B	8451	8 185	463.03
C	1106	1 064	84.87
E	9901	4 867	1 569.88
TOTAL	27 073	21 731	2 188.02

The following figure illustrates the average total unit cost of repairs to buildings with a B or C usability rating as a function of gross floor area.

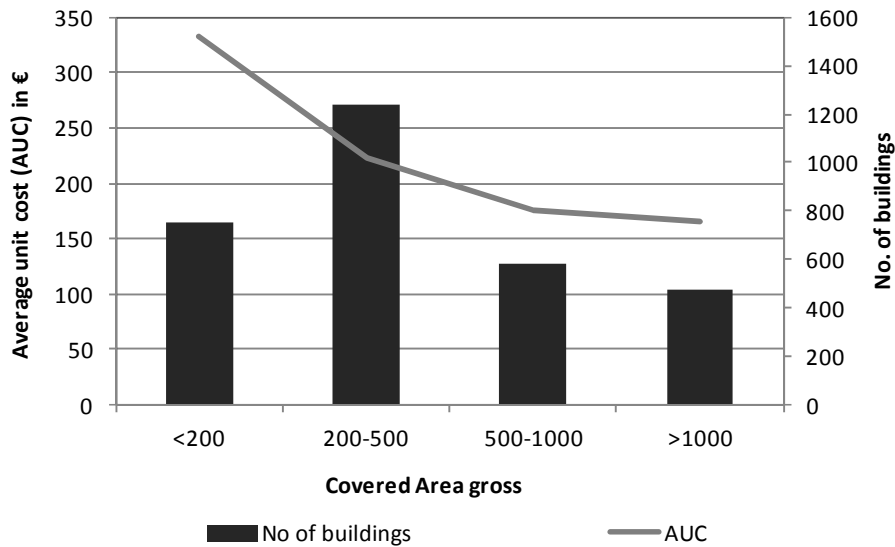


Figure 5: Average total unit cost of repairs to buildings with a B or C usability rating

By contrast, the complexity of repair projects and the consequent complexity of carrying out checks has caused long delays in granting funds to finance projects for more seriously damaged buildings (with "E" usability rating), thus leading to a backlog of several months in dealing with applications.

The initial absence of an upper limit to the size of a grant at first led to very overpriced estimates of the cost of repairs to buildings with the most damage. In many cases, the engineers consulted recommended elaborate, but extremely costly, solutions that were often not economically viable when considering the property's market value. In order to guarantee more efficient management of the funds available, the legislator introduced what has been coined "feasibility limit": the size of the grant given for repairs and seismic retrofitting of an existing building has been capped at the equivalent cost of constructing a brand new building of the same size. The actual implementation of this legislative amendment took several months, from May 2010, date of issue of Prime Ministerial Ordinance 3881 ratifying the principle of the feasibility limit, to December of the same year, date of publication of Government Commissioner's Decree No. 27 providing the implementation criteria.

The legislation in question set a time limit for processing grant applications and releasing funds with which the Municipalities' inspectorates rarely managed to comply. The average time needed to process applications for lightly-damaged buildings (B or C safety rating) was 140 days, instead of the 90 specified by the Act (the Act specified that a Municipality should process applications within 60 days, along with a further 30 days to allow the engineer in charge of the project to hand over additional paperwork). In the case of applications regarding more seriously damaged buildings, legislative requirements were completely ignored, since the average time necessary for the release of funding was 340 days. The figures below show the average time needed for the release of funding according to the quarter in which the application was submitted.

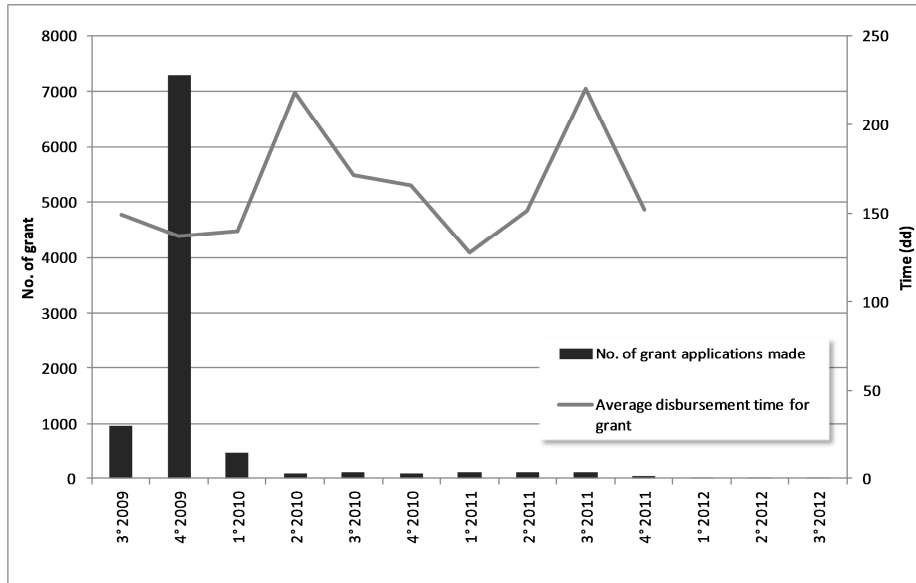


Figure 6: average time needed to release funding for lightly-damaged buildings

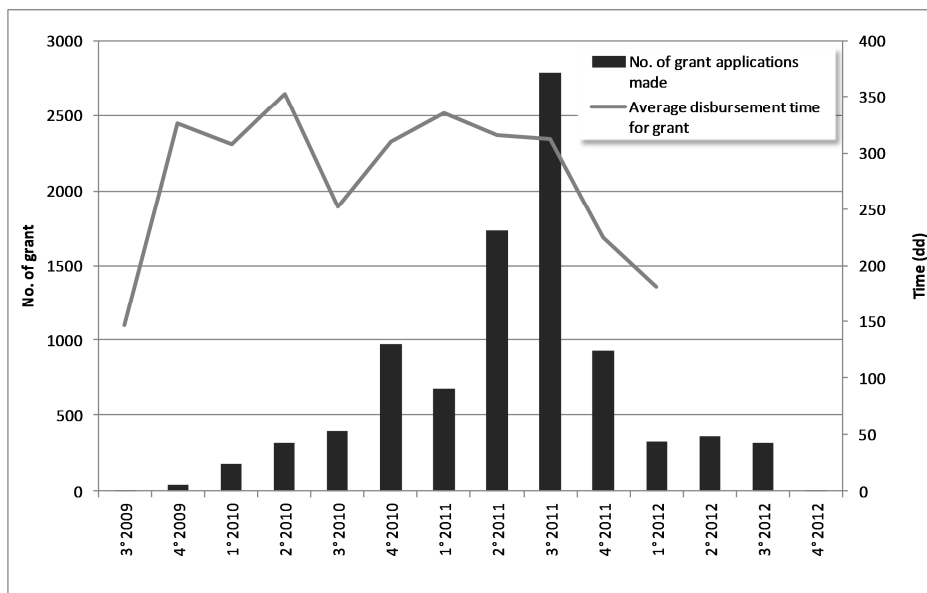


Figure 7: average time needed to release funding for seriously-damaged buildings

2.3 Delays in releasing funds for E-rated buildings

As previously stated, the checking and approval process of repair projects for buildings with an "E" rating took far longer than expected. Indeed, for seriously-damaged buildings, the Act specified that a Commune should process applications within 90 days, comprising 60 days for the Commune to examine the detail drawings and 30 days to allow the engineer in charge of the project to hand over additional paperwork.

The period in question above includes both the time needed to examine the project for which funding is sought and the time necessary for additional permits to be issued. To this end, the emergency legislation provides for streamlining of procedures regarding repairs to lightly-damaged buildings, equating them to routine maintenance operations. This equation has greatly simplified matters since Italian legislation covering this type of work merely requests that the Municipality receive written notice of commencement without imposing additional formalities. In the specific case of repairing earthquake damage, such notice was replaced by the grant application.

Conversely, as regards more seriously-damaged buildings, the emergency legislation makes no provision for fast tracking, therefore, the grant application must be submitted along with all plans and drawings specified by the current "Consolidated Building Act", Presidential Decree No. 380/2001.

Where the work entails demolition and reconstruction, the above-mentioned deadlines are extended to allow drafting and approval of the design for the new building, the Act granting an additional 140 days plus 30 days for handing over any additional paperwork.

The detailed analysis of the design enclosed with the grant application included both an assessment of the fairness of the estimate, involving checking the costs specified in the design, and checking the appropriateness of the type of workmanship employed and the work requested.

For every type of structure (reinforced concrete, masonry, industrial buildings), the designs for lightly-damaged buildings call for similar repairs. On the other hand, the designs for more seriously-damaged buildings are far more complex due to both the greater extent of damage and the complex nature of the requested seismic retrofitting. In this respect, it should be noted that Italian technical standards for construction provide for three levels of repair to existing buildings: local repair or reinforcement, restricted to certain structural members; seismic retrofitting that requires a set of operations to change the overall behaviour of the structure and thus increase its safety rating without actually reaching the safety level requested for brand new buildings; earthquake-resistant upgrade that requires a set of operations capable of providing an equivalent safety level to that requested for brand new buildings. The first type of work (local repair or reinforcement) involves surveying the individual structural members requiring repair without the need to quantify the overall improvement in the building's behaviour; this type of repair regards work that has little or no impact on the distribution of mass and stiffness and therefore little effect on the global behaviour of the building. Examples of such work include reinforcing reinforced-concrete structural members with carbon fibre (typically areas around joints, more rarely entire structural members), improving connections between floors or roofing and the walls of masonry buildings using metal ties and attaching non-structural elements to structures. For buildings with a B or C usability rating, bearing in mind the limited damage caused by the earthquake, the only grant available was for local reinforcement work aimed at strengthening local weaknesses in structural members and mitigating specific local structural and non-structural vulnerability.

The repetitive nature of the proposed work certainly facilitated the process of checking projects for B and C-rated buildings, unlike those for E-rated buildings for which the planned repair work was certainly far more complex and specifically adapted to suit the peculiar characteristics of each individual building. Furthermore, it should be remembered that structural repairs to any building seriously damaged by an earthquake generally require installing brand new or upgrading electrical systems, heating and plumbing in order to comply with current safety and energy-saving regulations. This lengthens the time required to complete design work and that needed to perform the necessary checks.

As regards the effectiveness of the checks carried out, an analysis of the grants approved for seriously-damaged buildings shows that of the amount requested totalling EUR 1,309,801.53, grants were given worth EUR 1,223,500,316.17, amounting to 93.4% of the total amount requested (figures updated to October 2012). The amount not approved for funding therefore totals EUR 86,301,133.76. For comparison purposes, it should be noted that in 2011 the amount paid by the Italian government to the owners of uninhabitable properties in order to provide temporary living accommodation totalled around 40 million euro.

3. Legislation implemented to manage the effects of the Emilia Romagna earthquake

3.1 Legislative changes

In the previous chapter we looked at the merits and limitations of the legislation adopted following the earthquake that struck the Abruzzo region in Central Italy in April 2009. About three years later, in May and June 2012, an earthquake swarm that reached its climax with three events of magnitude ranging from 5.0 to 5.9 Mw struck a large area of Northern Italy, mostly within the boundaries of the Emilia Romagna region. Unlike the 2009 earthquake, the area affected has a low population density, but a high concentration of businesses. The earthquake caused 17 deaths and made around thirty thousand buildings uninhabitable.

In many ways, the legislation implemented for reconstruction following this event is similar to that adopted following the 2009 earthquake in Central Italy, although with various changes aimed at generally speeding up grant approval procedures. More specifically, the following should be noted.

Despite three regions being involved in the 2012 earthquake, Emilia Romagna, Lombardy and Veneto (although the last two to a much lesser extent), unlike the 2009 earthquake, the twin legislative step (Prime Ministerial Ordinances/Government Commissioner Decrees) was eliminated since, as stated above, it had proved very difficult to put into practice. For the 2012 earthquake, following Act 74/2012, the only additional enactments are those by Government Commissioners (one Commissioner per Region who is the Chairman of that Regional Authority). The most important ordinances are issued simultaneously by the three commissioners in joint agreement. Following the 2009 earthquake, in order to regulate certain key aspects of the private reconstruction work, over a period of approx. 2 years, 10 Prime Ministerial Ordinances (Nos. 3778, 3779, 3790, 3803, 3805, 3820, 3832, 3881, 3897,

3945) and 11 Government Commissioner Decrees Nos. 3, 27, 40, 41, 43, 44, 45, 57, 59) were issued in addition to various Prime Ministerial Ordinances, Decrees and Circulars concerning secondary aspects. 6 months after the earthquake in Emilia Romagna, just three Ordinances have been issued (29, 51, 57), so far amended three times by additional corrective Ordinances.

The building safety rating is issued immediately after the main seismic event (surveys usually commence a few days afterwards) with a relatively short amount of time set aside for each property visited and it should be noted that inspections take place under difficult conditions due to the prevailing state of emergency. Further misunderstandings may arise if the maps utilised are not up to date or drafted accurately. This means there may be errors in assigning the safety rating that generally lead to a second survey being necessary. In the event of problems, the repeat survey or, in any event, the safety rating of damaged buildings that in 2009 called into play some extremely muddled procedures, has been simplified with a complete rewrite of the procedures for correcting multiple or incorrect ratings.

As part of the funding available, the 2009 legislation set aside specific funds for carrying out improvements to the damaged building. In particular, there were grants for the partial or total cost of work for improving the building's resistance to seismic actions, energy saving, making systems compliant with current safety legislation and the removal of architectural barriers. The introduction of specific limits for each of the types of work listed above was notably restricted, thus making it simpler to prepare the bill of quantities and conduct checks. This has also allowed designers to deal more easily with the specific conditions typical of every damaged building.

In the case of buildings like blocks of flats with more than one owner, the 2009 legislation called for the submission of a grant application by every owner affected and a further application by the property manager for communal areas. Therefore, for a block of flats with "n" different owners, the number of grant applications could be as many as n+1, thus placing those processing the applications under considerable pressure. On the other hand, the legislation implemented in 2012 simply calls for a single grant application to be submitted by the property manager. Multiple grant applications from every owner are no longer necessary and the division of the funds received between the various owners is merely recorded in the block's accounts. This simple amendment enables a notable reduction in the number of grant applications submitted for each building (on average 75%), making it much easier to process the applications received.

3.2 Demolition and new construction

In addition to several old town centres, including buildings of notable value, the 2009 earthquake also struck densely-populated suburbs, including reinforced-concrete buildings mostly constructed immediately after the Second World War. By introducing the feasibility limit with the enactment of Prime Ministerial Ordinance 3881, the legislator has shown that it can be more economically viable to demolish and rebuild damaged buildings rather than repair them. Such possibility was provided for by Prime Ministerial Ordinance 3881 enacted in 2010, about one year after the seismic event; however, the practical effects of said Prime

Ministerial Ordinance were postponed for several months until certain necessary implementing provisions were published. The 2009 reconstruction Act was the first to make express provision for owners to be offered the possibility of demolishing and building a new property should they see fit, even without exceeding the feasibility limit. The possibility of demolishing and reconstructing damaged buildings rather than repairing them, with the owner adding his own contribution to the Government grant, has not proved very popular. This is due to both the legislative delay and the information given to the public that was probably not very clear.

The legislation implemented following the 2012 earthquake is not yet complete at the time of writing this paper and currently fails to mirror the provisions of the previous 2009 Act.

4. Conclusions

Following the 2009 earthquake that struck Central Italy, legislation covering the reconstruction of private buildings was completely rewritten. In little more than three years, funding has been provided for around 22,000 sites, compared to around 27,000 grant applications. In the above-mentioned legislation, we can find plenty of pluses, but also several shortcomings, the latter being partly mitigated by the subsequent Act regarding the earthquake that struck Northern Italy in 2012 that has yet to be fully implemented. The difficulties that have emerged in dealing with the effects of the 2009 and 2012 earthquakes and the different ways in which they have been handled highlight all the limitations of the current Italian regulatory framework for managing post-emergency situations. In particular, there is no specific regulatory framework to provide guidance with regard to reconstruction and the return to normality following a disaster. This study provides a basis for drafting a new comprehensive law for post-earthquake measures. The aim is to establish a set of certain rules which can be applied to all large-scale seismic events. Regulatory certainty may promote greater use of insurance policies and operations to reinforce structures during scheduled maintenance work on the buildings.

References

Milano L., Marchetti L., Marsili C., Fontana G., Mannella A., Nola F. (2011). "Prime analisi dei costi di ripristino post-sisma del 6 aprile 2009 in Abruzzo e problematiche connesse ai rilievi di agibilità e danno", *Proceedings of the 14th ANIDIS Conference "L'ingegneria Sismica in Italia"*, September 18-22, 2011, Bari, IT.

Mannella A., Martinelli A., Mancini C., Di Pasquale G., Corina A. (2010). "Italy's Abruzzo region earthquake: building damage assessment activities", *Proceedings of the 14th European Conference on earthquake engineering*, August 30 – September 03, 2010, Scopje – Ohrid, Republic of Macedonia.

GNDT-SSN (1999). L'attività tecnica della Fase dell'emergenza. *Ingegneria Sismica*, n. 1, Patron Editore, Bologna, IT.

Baggio C., Bernardini A., Colozza R., Corazza L., Coppari S., Della Bella M., Di Pasquale G., Dolce M., Goretti A., Martinelli A., Orsini G., Papa F., Zuccaro G. (2000). "Manuale per la compilazione della scheda di I livello di Rilevamento Danno, Pronto Intervento e Agibilità per Edifici Ordinari nell'Emergenza Post-sismica". *Servizio sismico Nazionale e Gruppo Nazionale per la difesa dai Terremoti*.

Coppari S., Di Pasquale G., Goretti A., Orsini G., Papa F., Sabato S., Severino M. (2004). "Il terremoto del 2002 in Molise e Puglia: Sopralluoghi di Agibilità e Danno". *Ingegneria Sismica*, XXI, 1, 34-44, Patron Editore, Bologna, IT.

Dolce M., Di Pasquale G., Albanese V., Benetti D., Brammerini F., Coppari S., Corina A., De Rosa G., De Sortis A., Emili P., Ferlito R., Filippi L., Giordano F., Goretti A., Lo Presti T., Lucantoni A., Mercuri M., Moroni C., Orlandi N., Paoli G., Papa F., Pizza A., Procida F., Rinaldelli M., Sergio S., Severino M., Speranza E., Veschi A., Zambonelli E., Manfredi G., Di Ludovico M., Palermo G., Prota A., Verderame G., Corazza L., Cifani G., Mannella A., Martinelli A., (2009). "Quick surveys: post-earthquake usability inspections". *Progettazione Sismica*, n. 3, Pavia, IT.

Dolce M., Giovinazzi S., Iervolino I, Nigro E., Tang A. (2009). "Emergency management for lifelines and rapid response after L'Aquila Earthquake". *Progettazione Sismica*, n. 3, Pavia, IT.