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Web based evaluation of earthquake damages for reinforced concrete buildings

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Abstract. The first determination and assessment of the damages to structures after the earthquake is important for preventing increase in loss of life and property that may occur in later times. When rapid damage assessment is performed after an earthquake, damage assessment forms are generally used. The forms that are filled in the field are assessed in the office environment later. In this study, while the process of earthquake damage assessment was being carried out, the ready-made form was moved to web base and the data to be obtained in the field was transferred to the database by means of tablets and smart phones. Keeping earthquake damages in a database will contribute to the studies to be conducted on earthquake and the earthquake regulations to be prepared. Furthermore, emergency damage assessment will be performed faster and more reliably after the earthquake through this study. As the data transferred to the web base is accessible to different people, savings will be provided for both time and personnel. Furthermore, the assessment will have a healthier and scientific basis. In this study, exemplification was conducted for six different reinforced concrete buildings that were damaged during Van earthquake in October 23. With this study, damage assessment procedures can be completed as soon as possible.

Keywords: earthquake; damage assessment; reinforced-concrete; web based; database

1. Introduction

Particularly, destructive earthquakes in recent years and large-scale loss of life and property caused by these earthquakes lay emphasis on studies, researches and measures to be taken for earthquake. In this context, damage assessments after earthquake are one of the important steps of modern disaster management. The assessment and management of all information related to the structures damaged after an earthquake are important for spatial planning and urban transformation.

The estimation of anticipated damage by virtue of earthquakes for structures placed in seismically active regions is an issue of concern for design engineers and decision-making authorities in public- and private-sector organizations (Anoop and Rao 2015). It is also important to assess damage to buildings after the earthquake and decide to repair and reinforce or demolish them according to their damage level (Hadzima-Nyarko *et al*. 2017). For this reason, determining damage and making necessary reinforcement afterwards are one of the important issues of earthquake engineering and civil engineering (Celep and Kumbasar 2004). Assessment forms for earthquake damage determination are widely used. These forms are generally filled as a result of field investigations and then a final decision is reached regarding the structure as a result of assessments in the office environment. As a result of the investigations made after the earthquake, it is decided to be undamaged, mild, moderate and severe damage with respect to the structure. There is no need to fill the information in these forms for the building collapses.

The large number of damaged structures due to earthquake makes the damage assessment difficult in terms of time and personnel. However, damage assessment studies will be managed more effectively by transferring earthquake damages to a web-based environment. Considering the development process of information technology nowadays, tablets and smart phones are used in many sectors as a means of accessing information. It is very quick and easy to access a lot of information in this way. In this study, the damage assessments to be conducted for reinforced concrete structures after earthquake were moved to a database in electronic environment. The damage assessment form prepared by Republic of Turkey Prime Minister, Disaster and Emergency Management Presidency (AFAD) for reinforced concrete structures was used in the study. Six reinforced concrete buildings exposed to Van earthquake on 23 October 2011 were taken as examples. The damages related to the buildings that were investigated, were expressed and transferred to the web base. Later, the damage cases of these buildings were determined with the help of the forms created by AFAD. After this phase, the damage assessment forms prepared by AFAD were

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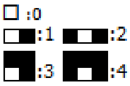
Table 1 Earthquake damage evaluation form for reinforced concrete buildings

DISTRICT	DATE
STREET / AVENUE	INVESTOR
BUILDING DOOR NO	
USAGE OF BUILDING	NUMBER OF STORIES
BUILT YEAR	TOTAL STORIES
SITUATION 	PLAN GEOMETRY 
THE STATE OF RC WALLS IN BASEMENT	COLLAPSE
STRUCTURAL SYSTEM TYPE	SHORT COLUMN
HEAVY OVERHANGS	WEAK / SOFT STORY
NUMBER OF RC COLUMNS AND RC WALLS	
NUMBER OF HEAVY DAMAGED COLUMNS	NUMBER OF HEAVY DAMAGED RC WALLS
NUMBER OF MEDIUM DAMAGED COLUMNS	NUMBER OF MEDIUM DAMAGED RC WALLS
NUMBER OF LIGHT DAMAGED COLUMNS	NUMBER OF LIGHT DAMAGED RC WALLS
NUMBER OF NO DAMAGED COLUMNS	NUMBER OF NO DAMAGED RC WALLS
DAMAGE STATUS OF NON-STRUCTURAL ELEMENTS	
ROOF /GAMBLE WALL DAMAGE	FUNNEL / PARAPHET DAMAGE
STAIRS DAMAGE	DAMAGE OF INFILL WALLS
NUMBER OF CORE SAMPLES	COMPRESSIVE STRENGTH OF CONCRETE

transferred to the electronic database and the damage assessments for these buildings were made in electronic environment. The images for the reinforced concrete structures that were investigated were also transferred to the database.

The aim of the study is to move the emergency damage assessments from the field to a database with the help of smart phones and tablets after the earthquake and to perform assessments from here. Thus, a database was created for earthquake damage assessments. Furthermore, an opportunity was provided for different persons to control the results of damage assessments remotely. This will make the results that will be obtained more realistic.

2. Methodology

Local governments have started to produce new information that collects, stores, processes and analyzes in the computer environment the location data they use for their service areas as a result of developments in computers, smart devices and internet technology.

In assessment and monitoring systems, the desire to benefit from information technologies has been increasing day by day. Accordingly, in the spread of mobile devices such as smart phones and tablets, that they have become a small computer system, they are wireless and can be portable and the presence of large memory capacity increased use of these devices. These elements have made compulsory to be monitored of environment control of mobile devices, monitoring of health services, and being used in many applications such as security, transport and automation (Diaz *et al*. 2014, Broeders *et al.* 2013, Ishigaki *et al*. 2013, Lee *et al*. 2013, Koukoumidis *et al*. 2012, Qin *et al*. 2014, Lehmann *et al*. 2012, Li *et al*. 2010, Sallabi *et al*. 2011, Arroqui *et al*. 2012, Delgado *et al*. 2013, Cunha *et al*. 2010, Gong *et al*. 2013, Sumriddetchkajorn *et al*. 2012, Chang *et al*. 2009, Zheng and Li 2010, Takao *et al*. 2012, Andrus *et al*. 2011, Liu *et al*. 2012). Structural control is a very broad field combining the areas of automatic control and structural engineering, with applications ranging from aerospace and mechanical engineering to building and civil infrastructure systems (Casciati *et al*. 2014). Technological advances in seismic instrumentation, digital communication and computer technologies enable the implementation of real-time early warning and rapid damage assessment systems also (Ordaz *et al*. 2017).

Earthquakes can increase great damage in life and property. In an earthquake, most of the casualties are due to the collapsed buildings, so building damage information extraction is the main task of earthquake damage information investigation. After an earthquake, the collapsed building information should be obtained in a timely manner, and it can be used to lead to the effective implementation of the emergency rescue, which is so vital for reducing the number of casualties (Zhai and Zeng 2017, Xian *et al*. 2016, Gautam *et al*. 2016).

Seismic disaster management and mitigation entail the establishment of an influential system (or methodologies) for evaluation of spatial information and earthquake hazard (Kim and Chuing 2016). In damage analysis which is based on observations, the key factor is to have a detailed and accurate building inventory and comprehensive damage data. Frequently, the inventory is partial and limited or only available for single towns, regions or provinces. Similarly, the quality of the damage data can be weak (Bessason and Bjarnason 2016). The damage information of buildings is crucial for rescue, humanitarian and reconstruction operations in the area of disaster. Building damage has been ranked in the field using damage scales (Sharma *et al*. 2017).

Historical earthquakes have indicated that successive seismic events may happen in highly seismic regions. Such a sequence of earthquakes has the potential to provide and increase in the damage level of the structures since any rehabilitation activity between the successive ground motions is practically impossible due to lack of time (Kostinakis and Morfidis 2017, Tang *et al*. 2016). When the reinforced concrete (RC) structures are exposed to earthquakes, they are likely to experience damage (Cao *et al.* 2014). The damage assessment in a reinforced concrete structure after an earthquake is performed for the purpose of taking decisions such as whether the building will be used immediately or whether it should be repaired or reinforced. The structural damage can be determined depending on the damage of the structural elements. It is firstly necessary to collect all types of data that can be obtained about the structure in order to assess the structure that is the basis of damage assessment. A complex study that depends on many parameters is required when assessing the buildings. This study constitutes the most important step in deciding whether they are to be repaired or reinforced. The mistake or deficiency in this phase leads to undesirable results. Failure to determine the damage levels of damaged buildings correctly will adversely affect life and property losses that may occur in a second earthquake. The best example of this is Bayram Hotel in Van city centre, it collapsed by the second earthquake and 25 people lost their lives.

When damage assessment is performed after the earthquake, the working conditions are very limited and it needs to be done in a short time. Depending on the magnitude of the damage caused by the earthquake, it may be difficult to find sufficient technical staff. Therefore, even the creation of teams that will assess damage can be a problem in terms of time. Information collection forms are used for damage assessment. In this study, the earthquake damage assessment form prepared by AFAD for reinforced concrete buildings, was taken into consideration (Taskin *et al*. 2015, Güler *et al*. 2015). The damage assessment after an earthquake can be done systematically through these forms. The damage assessment form after earthquake disaster was used for reinforced concrete buildings investigated in the study (Table 1). This form was filled for each building separately.

With these forms;

• The buildings that are heavily damaged shall be determined, more loss of lives shall be avoided by evacuating the people living in these buildings, available buildings shall be determined,

• Issues such as magnitude of earthquake, hazardous areas, the number of damaged buildings and economic loss shall be determined by using the information obtained,

• The results obtained by assessing the damages shall be used for the planning of helping, repairing and reinforcing works of the structures and for the design of the structures to be newly constructed, and the regulations records shall be reviewed. (Taskin *et al*. 2015, Guler *et al*. 2015).

• Necessary planning operations shall be carried out in order to sustain life activities for earthquake zones.

• Earthquake zones can be determined more realistically by processing the obtained building data on maps.

• The spatial and administrative operations to be carried out after the earthquake shall be performed systematically.

Those who will fill the earthquake damage assessment form should first be trained on how to fill the form. As a result of this process, field studies will be faster and more reliable. The success of data collection often depends largely on this preparation. Otherwise, field studies are required to be renewed in order to collect data.

It is important to prepare the information form so that a computer can assess it. Thus, results can be obtained in a short period and information can be assessed by the availability of the building and the settlement areas depending on the damage levels, and the results can be obtained in the form of graphics. Furthermore, the relationships between the loss of life, which is the most important issue in the earthquake, and the level of damage system in the buildings and the type of bearing system can be obtained. For the buildings subjected to damage assessment, images are also transferred to the database

3. Investigated reinforced-concrete (RC) buildings

Fig. 1 Pictures of 1. building

Table 2 Damage evaluation form parameters for 1. building

DISTRICT	ALIPAŞA	DATE	14.05.2012
STREET / AVENUE		INVESTOR	
BUILDING DOOR NO			
USAGE OF BUILDING	RESIDENCE	NUMBER OF STORIES	B+Z+4 NK
BUILT YEAR	1996	TOTAL STORIES	6
SITUATION (:0, :1, :2, :3, :4)	0	PLAN GEOMETRY (:1, :2)	1
THE STATE OF RC WALLS IN BASEMENT	YES	COLLAPSE	NO
STRUCTURAL SYSTEM TYPE	REINFORCED-CONCRETE (RC)	SHORT COLUMN	NO
HEAVY OVERHANGS	NO	WEAK / SOFT STORY	NO
NUMBER OF RC COLUMNS AND RC WALLS			
NUMBER OF HEAVY DAMAGED COLUMNS	1	NUMBER OF HEAVY DAMAGED RC WALLS	0
NUMBER OF MEDIUM DAMAGED COLUMNS	9	NUMBER OF MEDIUM DAMAGED RC WALLS	0
NUMBER OF LIGHT DAMAGED COLUMNS	8	NUMBER OF LIGHT DAMAGED RC WALLS	0
NUMBER OF NO DAMAGED COLUMNS	8	NUMBER OF NO DAMAGED RC WALLS	0
DAMAGE STATUS OF NON-STRUCTURAL ELEMENTS			
ROOF /GAMBLE WALL DAMAGE	NO	FUNNEL / PARAPHET DAMAGE	NO
STAIRS DAMAGE	NO	DAMAGE OF INFILL WALLS	NO
NUMBER OF CORE SAMPLES	9	COMPRESSIVE STRENGTH OF CONCRETE	10,66 MPA
Damage status of RC beams			
In case of more than one beam which crack width due to shear and/or bending where near the supports>2 mm		Additive to damage (HK1)	
In case of more than one RC beam which crack width >2 mm		HK1 =	0,1
In case of no beams which crack width <2 mm		HK1 =	0

A destructive earthquake happened at 13:41 in 23.10.2011 in Van of which M_w=7.2. The earthquake has been felt in some settlements, especially in Lake Van Basin where earthquake has always been neglected. The earthquake epicentre was located directly between Erciş district and Van City. The maximum structural losses observed in Van and Erciş District. Erciş district was the most heavily damaged area in this earthquake. The first damage assessment of constructions after earthquake and its evaluation have importance in order to prevent loss of life and property in coming earthquakes (Işık *et al.* 2012, Işık 2016). In this context, the evaluations obtained for six reinforced concrete buildings exposed to Van earthquake are given below.

3.1.1 Building

From the building in the form of B+Z+4NK which is

Table 3 Damage information for 1.building

Structural system damage information					
This form will be filled for the story where the greatest damage observed.					
The total number of columns and RC walls will be determined for the story where the greatest damage observed.					
Number of heavy damaged of vertical elements				Slip-damaged element in junction area / Buckling in rebar /Stripped reinforcement element /The element which has shear crack (crack width>= 2mm)/ The element which has bending crack (crack width >= 2mm)	Weighted number of vertical elements
Columns		RC Walls			
C1 =	1	P1 =	-		T = ∑ Ci + 2 * ∑ Pi (T) = 26
Number of medium damaged of vertical elements				Slip-damaged element in junction area /The element which has shear crack (crack width 1mm ~ 2mm) / The element which has bending crack (crack width 1mm ~ 2mm) /Corrosion cracked	Weighted number of heavy and medium damaged vertical elements (H)
Columns		RC Walls			
C2 =	9	P2 =	-		H = C1 + 2 * P1 + 0,9 *(C2 + 2 * P2)
Number of vertical elements not damaged				The element which has shear crack (crack width <1mm) / The element which has bending crack (crack width <1mm) / The element without any damage	
Columns		RC Walls			
C3 =	16	P3 =	-		H = 1 + 0,9*9 = 9,1
Total number of vertical elements.					
Columns		RC Walls			H = 9,1
∑ Ci =	26	**∑ Pi =**	-		

consisted a total of 6 stories, it was observed that the greatest damage occurred on the ground floor on a reinforced concrete frame building. In the building, no partial or total collapse condition was observed. Also, no heavy closure condition, no soft/weak story condition and no short column condition were detected. There was no evidence of liquefaction in the examinations made on the ground. Roof/gamble wall damage, chimney/parapet damage, infill walls damage and staircase damage were not observed in the damage assessments made for non-structural system elements in the general area of the building. From 26 bearing elements that can be examined in the building; 1 heavy damaged columns, 9 medium damaged columns, 8 slightly damaged columns and 8 no damage columns were detected. Commonly, column-beam joint damage has been detected. Experiments carried out on the core samples taken to determine the concrete strength have showed that the concrete strength was 10.66 N/mm^2 (C10). Fig. 1 shows some images from the building number 1.

Table 2 shows the parameters obtained for 1. building by using Table 1 in terms of appearance in this study.

The damage case of the building was decided by the damage assessment forms filled as a result of the field studies conducted for each building that will be investigated

Table 4 Status of the damage for 1.building

Damage status of RC beams		
In case of more than one beam which crack width due to shear and/or bending where near the supports>2 mm	Additive to damage (HK1)	
In case of more than one RC beam which crack width >2 mm	HK1 =	0,1
In case of no beams which crack width <2 mm	HK1 =	0

Table 5 Ground damage status for 1. building

Damage status of basement ground		
Z- Ground collapse (liquefaction) (If no , Z = 1 ; If yes Z = 1,2)		
YES	Z =	1
NO	Z =	1,2

Table 6 Status of damage for non-structural elements for 1. building

Status of damage for non-structural elements									
N1 – Gamble wall damage		N2 – Staircase damage		N3 – Flue or parapet damage		N4 – Shear Damage at infill walls		Additive to damage (HK2)	
If YES 1 ; If NO 0		If YES 1 ; If NO 0		If YES 1 ; If NO 0		If YES 1 ; If NO 0		0,0125 * (N1 + N2 + N3 + N4)	
NO		NO		NO		NO		HK2 =	0
N1 =	0	N2 =	0	N3 =	0	N4 =	0		

and then by the equations stated in the form in the office environment. For each building to be investigated it is checked whether there is a collapse in the building and if there is a collapse, it is not necessary to fill this form. When the damage assessment is performed for any building that does not collapse, the damage information of the bearing system is obtained first. The information to be used for bearing system damage is given in Table 3 and it was filled for building no.1 as an example. In this section, the vertical structural elements (columns and RC walls) in the structure are taken into account. Heavy, medium, other and total numbers are used as data for the vertical bearing elements. Table 3 shows how damage cases are decided.

T value represents the total number of all vertical structural elements as columns and RC walls. H value represents the total number of heavy and medium damaged columns and RC walls. Different weighted coefficients are used for column and RC walls. After filling the information for the vertical bearing members, the damage condition for the beams in the structure is decided. Table 4 shows the damage cases of reinforced concrete beams of building 1.

After the data for the structural elements have been obtained, the damage of the structural foundation soil is taken into account.

Damage due to foundation soils for building number 1 was shown in Table 5. This value was chosen as 1 because no damage was found on the ground.

Damage conditions of non-structural system components are also used as data before the damage evaluation process. Table 6 shows which values of non-bearing system elements are to be used and what are the value of these data for the building number 1. In case the parameters mentioned in Table 6 exist, value 1 is used for each parameter.

The damage is graded for the structural system

Table 7 Damaged evaluation for 1.building

Damaged evaluation for structural system elements					
Damage Ratio	Total Damage Score	THO * 100 =		45	
		>= 40	40 > THO >= 20	20 > THO > 0	= 0
HO = (H / T)	THO = HO * Z + HK1 + HK2	HEAVY	MEDIUM	SLIGHTLY	NO DAMAGE
HO = 0,35	THO = 0,45	X			

Fig. 2 Pictures of 2. Building

components after all the damage cases specified in the damage assessment form have been determined. Four different damage grades which are no damage, slightly, medium and heavy are used. In order to make this decision, the damage rate and the total damage score are calculated using all the parameter values mentioned above. How these are calculated, and as an illustration the damage rating for structural system components for building 1, are shown in Table 7.

3.2.2 Building

From the building in the form of B+Z+4NK which is consisted a total of 6 stories, it was observed that the greatest damage occurred on the ground floor on a reinforced concrete frame building. In the building, no partial or total collapse condition was observed. Also, no heavy closure condition, no soft/weak story condition and no short column condition were detected. There was no evidence of liquefaction in the examinations made on the ground. Roof/gamble wall damage and staircase damage were not observed in the damage assessments made for non-structural system elements in the general area of the building; however, chimney/parapet and shear damage in infill walls was observed. From 19 bearing elements that can be examined in the building; 2 heavy damaged columns, 5 medium damaged columns, 5 slightly damaged columns and 7 no damage columns were detected. Commonly, column-beam joint damage has been detected. Experiments carried out on the samples taken to determine the concrete strength have showed that the concrete strength was 10.65 N/mm^2 (C10). Fig. 2 shows some images from the building number 2.

3.3.3 Building

From the building in the form of B+Z+3NK which is consisted a total of 5 stories, it was observed that the greatest damage occurred on the ground floor on a reinforced concrete frame building. In the building, no partial or total collapse condition was observed. Also, no heavy closure condition, no soft/weak story condition and

Fig. 3 Pictures of 3. Building

Fig. 4 Picture of 4. Building

no short column condition were detected. There was no evidence of liquefaction in the examinations made on the ground. There was no RC wall in the building. Roof/gamble wall damage and staircase damage were not observed in the damage assessments made for non-structural system elements in the general area of the building; no damage at chimney) parapet however, shear damage in infill walls was observed. Damage in infill walls was observed commonly.

Diagonal cracks, out-of-plane overturns have formed in the infill walls. From 24 bearing elements that can be examined in the building; 4 slightly damaged columns and 20 of the have no damage columns were detected. Commonly, column-beam joint damage has been detected. Experiments carried out on the samples taken to determine the concrete strength have showed that the concrete strength was 17.22 N/mm^2 (C16). Figure 3 shows some images from the building number 3.

3.4.4 Building

From the building in the form of Z+4NK which is consisted a total of 5 stories, it was observed that the greatest damage occurred on the ground floor on a reinforced concrete frame building. In the building, no partial or total collapse condition was observed. Also, no heavy closure condition, no soft/weak story condition and no short column condition were detected. There was no evidence of liquefaction in the examinations made on the ground. There was no RC wall in the building. Roof/gamble wall damage, chimney/parapet damage, infill walls damage and staircase damage were not observed in the damage assessments made for non-structural system elements in the general area of the building. From 36 bearing elements that can be examined in the building; 36 of the have no damage

Fig. 5 Pictures of 5. Building

Fig. 6 Picture of 6. Building

columns were detected. Experiments carried out on the samples taken to determine the concrete strength have showed that the concrete strength was 17.73 N/mm^2 (C16). Fig. 4 shows some images from the building number 2.

3.5.5 Building

From the building in the form of Z+3NK which is consisted a total of 4 stories, it was observed that the greatest damage occurred on the ground floor on a reinforced concrete frame building. In the building, no partial or total collapse condition was observed. Also, no heavy closure condition, no soft/weak story condition and no short column condition were detected. There was no evidence of liquefaction in the examinations made on the ground. Roof/gamble wall damage, chimney/parapet damage and staircase damage were not observed in the damage assessments made for non-structural system elements in the general area of the building; however, shear damage in infill walls was observed. From 20 bearing elements that can be examined in the building; 5 medium damaged columns, 3 slightly damaged columns and 12 no damage columns were detected. There were no RC walls in the building. Commonly, column-beam joint damage has been detected. Shear cracks were found in the columns. Experiments carried out on the samples taken to determine the concrete strength have showed that the concrete strength was 9.85 N/mm^2 (C9). Figure 5 shows some images from the building number 5.

3.6.6 Building

The primary school of Gedikbulak, built in 1980's and totally collapsed during the October 2011 Tabanlı earthquake. Half of the building has collapsed in pan-cake shape. The RC walls, though quite large, they still failed at the ground floor. The RC walls, though quite large, they still failed at the ground floor. The structural members were observed to be laid out improperly in some of the buildings. Improper layout of the structural members was conceived to be one of the major causes of collapse of school building in Gedikbulak village. Gedikbulak School building has been collapsed by the moving of RC walls from their axes (Kutanis *et al*. 2013).

Damage evaluation for buildings subject to inspection was given in Table 8.

Table 8 Damage evaluation of investigated buildings

BUILDING ID	1	2	3	4	5
C1	1	2	0	0	0
C2	9	5	0	0	5
C3	16	12	24	36	15
∑C	26	19	24	36	20
P1	0	0	0	0	0
P2	0	0	0	0	0
P3	0	0	0	0	0
∑P	0	0	0	0	0
T	26	19	24	36	20
H	9	7	0	0	5
HK1	0,10	0,10	0	0	0,10
Z	1	1	1	1	1
N1	0	0	0	0	0
N2	0	0	0	0	0
N3	0	1	0	0	0
N4	0	1	1	0	1
HK2	0	0,025	0,0125	0	0,0125
HO	0,35	0,342	0	0	0,225
THO (%)	0,45	0,467	0,0125	0	0,338
THO	45	46,7	1,25	0	33,80
DAMAGE EVAULATION	HEAVY	HEAVY	SLIGTHLY	NO DAMAGE	MEDIUM

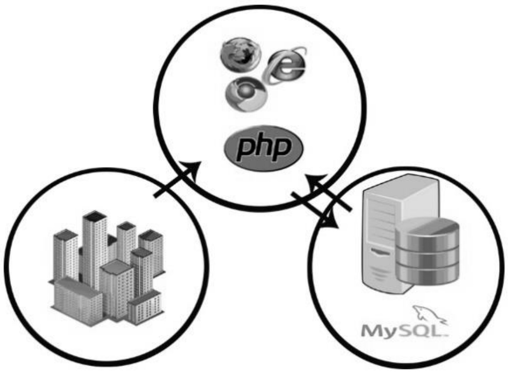
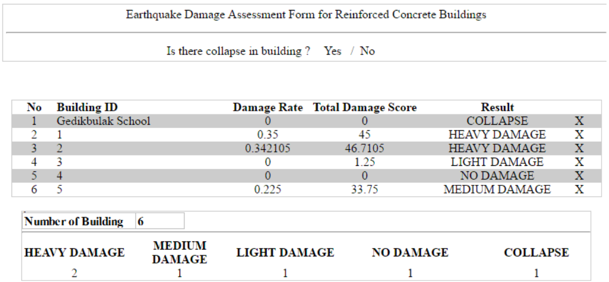


Fig. 7 Algorithm of software system operation

4. Web based evaluation

The first step in protecting a settlement from an


Earthquake Damage Assessment Form for Reinforced Concrete Buildings

Is there collapse in building ? Yes / No

No	Building ID	Damage Rate	Total Damage Score	Result	
1	Gedikbulak School	0	0	COLLAPSE	X
2	1	0.35	45	HEAVY DAMAGE	X
3	2	0.342105	46.7105	HEAVY DAMAGE	X
4	3	0	1.25	LIGHT DAMAGE	X
5	4	0	0	NO DAMAGE	X
6	5	0.225	33.75	MEDIUM DAMAGE	X

Number of Building 6

HEAVY DAMAGE	MEDIUM DAMAGE	LIGHT DAMAGE	NO DAMAGE	COLLAPSE
2	1	1	1	1

Fig. 8 Home page for damage assessment

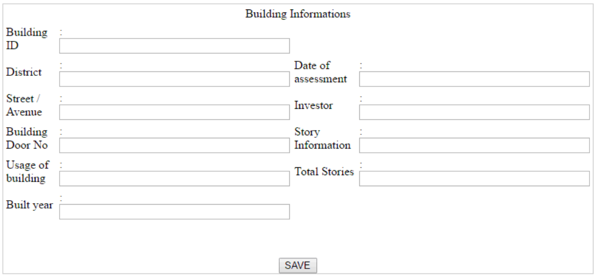


Fig. 9 Data entry for collapse

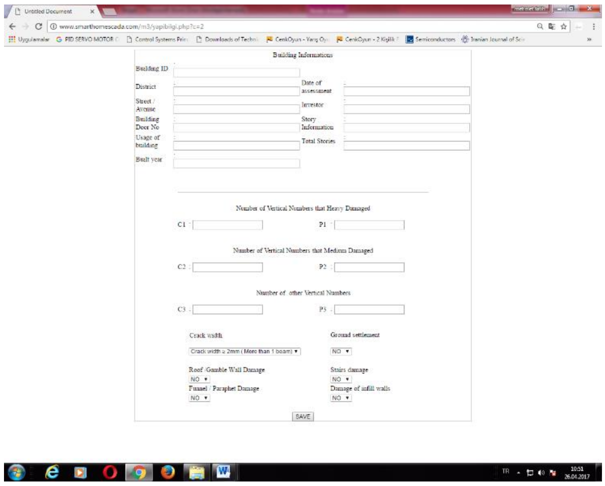


Fig. 10 Data entry screen in case of non-collapse

earthquake disaster is to form and possess a theoretical prediction of the consequences: structural damage as well as socio-economic losses that may happen after the occurrence of the earthquake. In fact, it is crucial to assess the effects of any potential earthquake in order to prepare for management during catastrophic situation. As well as anticipating and taking appropriate measures to reduce the vulnerability and expected losses on the part of guaranteeing urban resilience (Hadzima-Nyarko *et al.* 2016). In this context, it is important to evaluate earthquake damages rapidly. This can be done using a web-based damage assessment.

Web-based evaluation software consists of the designs of interface and database. While the web interface software was developed in the language of php, MySQL was used to the database. MySQL has an extremely useful property in terms of flexibility and speed in the web-based software's. A proper calculation pattern was done for a rapid evaluation with the web-based software which was developed. The parts which the images belonging to the building were comprised as near to the information belonging to the building which the evaluation will be done on the interface software. Fig. 7 present algorithm of web based evaluation.

A website with the name of http://www.smarthomescada.com/m3/index.php which is associated with php base and MySQL data base was prepared for the evaluation of earthquake damages. It was aimed that the earthquake damages are determined quickly and in a reliable way through this site. The evaluation of buildings after an earthquake is done through the site and each of buildings is assessed on the base of their ID numbers. The data which is entered for the building is assessed in two different cases. First one is that the data belonging to the building is recorded on the database in a case of the collapse in a building and the process of recording is gone on as "COLLAPSE" onto the section of conclusion on the database without requiring any data entry. The image of this case was presented at Figs. 8 and 9.

At Fig. 8, the personnel who entries the data on the site was asked about "is there a collapse". If it is available, the process of data entry is done onto the parts which were shown at Fig. 9; the process is completed after the images belonging to the building are entered. At the end of this process, the information that a building is the collapse one was recorded onto the database.

Another case is that the building hasn't got any collapse. When the response of "no" was given to the question "is there a collapse" at the Fig. 8, the form which is shown at Fig. 10 is opened. The information belonging to the building is entered via this form. At the end of this processing, the data is sent to the database as the save key is clicked. As following this phase, the process is completed with the instant photo shoot of the images belonging to the building or with the addition of photos which are taken from the current gallery. It is assessed as heavy damage, medium damage, slightly damage, no damage or collapse on the base of the data which is calculated after this phase, and it is put to the evaluation as a statistical data.

As it is shown at Fig. 11, it provides an opportunity of situation assessment for the person who examines as a statistic is recorded for the buildings that the recording process of database is done with the list belonging to the buildings that are recorded onto the database as a result of these processes, and with the damage situations. Thus, the buildings which are put to the evaluation are examined together on the region where the examination is done. On the other saying, it is prevented that a building is assessed by the different persons and it provides an opportunity to the evaluation of the process in a quicker and perspicuously as the personnel who make the different examinations use the same database. It is expected that the number of user's increases globally as the web page which was developed has a structure which can be used not only for a region or person but by everyone and for each of regions. When there is an increase in the number of the site's active users, it will be started that the online evaluation system of earthquake damages is used actively. So the proper analysis system will have been occurred for both of the authorities and the scientists.

Earthquake Damage Assessment Form for Reinforced Concrete Buildings

Is there collapse in building ? Yes / No

No	Building ID	Damage Rate	Total Damage Score	Result	
1	Gedikbulak School	0	0	COLLAPSE	X
2	1	0.35	45	HEAVY DAMAGE	X
3	2	0.342105	46.7105	HEAVY DAMAGE	X
4	3	0	1.25	LIGHT DAMAGE	X
5	4	0	0	NO DAMAGE	X
6	5	0.225	33.75	MEDIUM DAMAGE	X

Number of Building 6

HEAVY DAMAGE	MEDIUM DAMAGE	LIGHT DAMAGE	NO DAMAGE	COLLAPSE
2	1	1	1	1

Fig. 11 Result screen of earthquake damage evaluation for RC buildings

Moreover, the limitations were given for some parts and the optional entry was done for some parts in order that the erroneous entry isn't done by the users during the data entry in the software. When the manager wants to regulate the parameters of the building again or wants to delete the information belonging to the building, he/she would regulate on condition with choosing the building.

5. Conclusions

The damage assessment processes of the reinforced-concrete buildings which are exposed to an earthquake in the settlements were taken to the electronic media, and the damage grading was done on the electronic media for each of the buildings with this study. The information which required be receiving or demanding from the different institutions was gathered on MYSQL database which would work quickly on the internet, with the help of this media which was comprised.

It was aimed with this study that an electronic database is done for the reinforced-concrete buildings and a database is done for the buildings which experienced an earthquake. It is foreseen that the information which is obtained is used to decrease the effects of dangers which would occur in a possible earthquake.

It has an importance for the buildings' damages are evaluated in a systematic way and for the assessment of damages and loss of life which occur as its result. This study can be used as a tool of decision-support in the studies related to the relation between the earthquake and building. The data which was gathered from the site was integrated onto the electronic media and the data which was obtained was shared in a healthy, easy and quick way.

This study will have an importance in the sense of taking from these damages and about which type of structures whichever damages have after a possible earthquake. The earthquake intensity, its various damage extents and the number of usable buildings will be determined with the data which were transferred to the electronic media. As its result, the people's main events can be easily regulated.

The earthquake zones would be determined in more realistic way with this database which will be comprised of the buildings, while the disaster management is organised in a better way as the data related to the buildings is categorized in a systematic way. A source will be prepared for the advanced studies which will be done about this subject. The properties of the buildings which are damaged and of the construction elements that the bring out are determined and so, it can be provided that the danger of an earthquake is decreased with the use of this information to plan and design project of the buildings which will be constructed newly. This will contribute to the development of regulations on the current earthquake, project designing and the construction.

The public institutions and organisations related to the local authorities would get directly the building stocks which are exposed to an earthquake and the data and when they demand, they would get the availability of the data on the electronic media, with this study. The damaged assessment on the buildings, their categorisation and the decision-making process for them would be done in a controlled way with the help of the data related to the buildings after an earthquake.

All the data can be described in an associated form in an activated and detailed way on a single database with the system which is installed; they can be saved, processed and analysed. So, it can save in time and financial aspects for the processes of decision-making and implementation and it can make an institutional resource planning background.

It would be used actively to make an information-based management process and the information-based strategically plan with the construction information system substructure which is consistent with the method which is considered in the study. Moreover, an opportunity to get the building stocks' data as an independent from the place that are exposed to an earthquake will be gotten, which would be obtained from the study. This study would be extended with the new modules. Its prosecution would be done easily.

The following situation reveals the result that the evaluations related to the buildings are not very realistic due to the lack of time and technical personnel; the building stocks which are exposed to an earthquake are too many. There is a need for the rapid damage assessment methods in the event that these evaluations would give the healthy results scientifically. In regard to this need, the damage assessment forms were prepared by AFAD. It is possible to determine some parameters which would affect the building's act under an earthquake, partly without entering into the building or from the internal parts of the building. The damage extent on the buildings is determined with this calculation.

It cannot be said in a definite way about whether these buildings which their damage extent is designated are proper the regulation of earthquake or not. As it is stated above, this is only a rapid damage assessment study. Thus, the definite result will be gotten as a result of the definitive analysis methods. This method is a process which is done to remove the effects of a possible second earthquake.

The damage assessment processes which will be done comprise the main step of the process for maintenance and strengthening. All the processes from the assessment of damage class to the phase of practical project should be done by the specialist and experienced engineers. It will make the results to be obtained as more valuable ones that the sufficient numbers of expert personnel in their subject are employed in the event that the damage assessments on the buildings after an earthquake would be done rapidly and in a way to provide the demanded results. So, the damage assessment criteria and the damage assessment forms should be done before starting the process of damage assessment, and the necessary trainings related to how these forms will be filled should be provided.

It is important that the urban planning which is regulated in consideration with the earthquake's effects on the zones where the new structuring will be done and the regulations of land usage are done. Moreover, it will be one of the precautions which will be taken to decrease the earthquake's damages; that the current buildings are reviewed and the necessary precautions are taken.

The building sector which is at the head of the locomotive sectors in the country economy consumes the great part of foreign resources with the great part of public and private sectors. The usage of resources in the efficient way is the main activity of improvement moves. Thus, the cost studies which will be done to decide on whether the buildings which are damaged or would be damaged are strengthened or they are reconstructed should be done by the experts sensitively.

The size of earthquakes and the negative structural features have been caused an increase in damage amount. Knowing the properties of buildings that have negatively effect to the seismic behaviour of buildings under earthquakes will be put forward to ensure more serious approaches for reduce the level of damage risk after earthquakes.

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