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Evaluation of rapid screening parameters and suggestions for urban transformation of reinforced concrete buildings

Betonarme yapıların kentsel dönüşümünde, hızlı tarama parametrelerin değerlendirilmesi ve öneriler

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Abstract

Recent earthquakes have shown that urban transformation has become a necessity for many cities in Turkey to achieve livable conditions and to ensure the safety of life and property of the citizens. In order to fulfill the need for urban transformation in the country, "General Directorate of Infrastructure and Urban Transformation Services" has been established under the Ministry of Environment, Urbanization and Climate Change since 2013, and building-based and area-based urban transformation has been carried out. activities are coordinated by this institution. Within the framework of area-based Urban Transformation planning, areas with high-risk buildings in terms of earthquake hazard are determined by using the First Stage Evaluation Method included in the annex of the Law No. 6306 Enforcement Regulation. It was observed that the method was insufficient to determine the risk situations of buildings and was not very compatible with the detailed analysis results. In this study, new parameters to be used in addition to the parameters used for the "First Stage Evaluation Method" were studied and it was aimed to determine the risk situation in the determined region more appropriately. In this context, 402 buildings, whose risk status was determined by static analyses from the database of the Ministry of Environment, Urbanization and Climate Change, were used. To achieve this, the parameters that may cause the buildings that are determined to be risky to be risky are determined in the database and the contributions of these determined parameters to the risky of the building are ranked from the most effective to the least using the following methods: SPSS statistical analysis software. In addition, the parameters used in the "First Stage Evaluation Method" were interpreted.

Keywords: Urban transformation, Law no. 6306, Risky and risk-free buildings, Rapid screening, Risky space.

Öz

Yaşanan son depremler göstermiştir ki, Türkiye'de birçok kent için yaşanabilir koşullara ulaşmak, kentlilerin can ve mal güvenliğinin sağlayabilmek için kentsel dönüşüm bir zorunluluk haline gelmiştir. Ülkedeki kentsel dönüşüm ihtiyacını karşılamak amacıyla 2013 yılından itibaren Çevre, Şehircilik ve İklim Değişikliği Bakanlığı bünyesinde "Altyapı ve Kentsel Dönüşüm Hizmetleri Genel Müdürlüğü" kurularak bina bazlı ve alan bazlı kentsel dönüşüm gerçekleştirilmektedir. faaliyetler bu kurum tarafından koordine edilmektedir. Alan bazlı Kentsel Dönüşüm planlaması çerçevesinde deprem tehlikesi açısından yüksek riskli yapılara sahip alanlar 6306 Sayılı Kanun Yürürlük Yönetmeliği ekinde yer alan Birinci Aşama Değerlendirme Yöntemi kullanılarak belirlenmektedir. yöntemin binaların risk durumlarını belirlemede yetersiz kaldığı ve detaylı analiz sonuçlarıyla pek uyumlu olmadığı görüldü. Bu çalışmada "Birinci Aşama Değerlendirme Yöntemi" için kullanılan parametrelere ek olarak kullanılacak yeni parametreler üzerinde çalışılmış ve belirlenen bölgedeki risk durumunun daha uygun şekilde belirlenmesi amaçlanmıştır. Bu kapsamda Çevre, Şehircilik ve İklim Değişikliği Bakanlığı veri tabanından statik analizlerle risk durumu belirlenen 402 bina kullanıldı. Bunu gerçekleştirmek için veri tabanında riskli olduğu belirlenen binaların riskli olmasına neden olabilecek parametreler belirlenmiş ve belirlenen bu parametrelerin binanın riskliliğine katkıları en etkili olandan en aza doğru aşağıdaki yöntemler kullanılarak sıralanmıştır: SPSS istatistiksel analiz yazılımı. Ayrıca "Birinci Aşama Değerlendirme Yöntemi"nde kullanılan parametrelerin dair değerlendirmeler yapılmıştır.

Anahtar Kelimeler: Kentsel dönüşüm, 6306 Sayılı Kanun, Riskli ve risksiz yapılar, Hızlı tarama, Riskli alan.

1 Introduction

Anatolia is situated within a region characterized by notably frequent and highly intense seismic activity, resulting in the occurrence of substantial and destructive earthquakes. This perilous condition has led to the construction of a significant portion of the nation's building inventory without the involvement of engineering expertise, rendering these buildings highly vulnerable to potential seismic events. The historical record of past earthquakes, marked by significant loss of both human life and property, underscores the urgency and imperative nature of urban transformation initiatives aimed at the renovation and fortification of these non-resilient buildings.

Since 2013, Law No. 6306 on the Transformation of Areas under Disaster Risk and the Implementing Regulation of this Law have been published to provide legal basis for urban transformation activities against earthquakes and it carries out urban transformation activities in line with these provisions.

In recent times, the provinces of Kahramanmaras, Hatay, Adıyaman, Malatya, İzmir, and Elazig have experienced significant structural damage and tragic loss of life because of

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earthquakes. Additionally, a concerning observation has come to light regarding the presence of self-demolishing buildings in Istanbul. This unsettling revelation underscores the overall precarious state of the nation's building stock, even in the absence of seismic events. Consequently, it reaffirms the urgency of addressing and promptly urbanizing these high-risk buildings. To expedite urban transformation endeavours, the Ministry of Environment and Urbanization is actively identifying areas at risk, initiating urban renewal projects in these designated zones.

In the process of delineating and officially designating an earthquake-prone area, conducting a comprehensive static analysis of all buildings in the area can significantly complicate the evaluation process and incur significant initial costs. To obtain an initial assessment of the vulnerability of the building stock in each region, a more expedient approach is to use the "First Stage Evaluation Method" as outlined in the Guidelines for the Assessment of Buildings Under High Risk [1]. This method allows for a rapid screening of all buildings within the area under study, assigning a score to each building based on predetermined criteria. Subsequently, the classification of an area as high risk may depend on the number of buildings identified as vulnerable because of this scoring process.

In the First Stage Evaluation Method, Load Bearing System Type, Number of Storeys, Current Situation and Appearance, consist of soft - weak storey, vertical irregularities, consist of overhang, plan irregularities, consist of short column effect, consist of hammering effect, neighbouring formation, and neighbouring slab levels in adjacent buildings, seismic zone of located building and slope of soil parameters are taken into consideration. In addition to these parameters determined in the method, it is thought that the method will give better results by including additional parameters that may affect the earthquake risk of buildings in this evaluation method. Building age, concrete strength, tensile strength of reinforcement and whether ribbed reinforcement is used are considered as important parameters that may affect whether the buildings are earthquake risky or not. The inclusion of these parameters as additional parameters in the First Stage Assessment Method is expected to contribute to a more accurate estimation of the riskiness of the method. Building age, concrete strength, and tensile strength of reinforcement and whether ribbed reinforcement is used are considered as important parameters that will affect whether the buildings are risky or not in terms of earthquake. It is predicted that the inclusion of these parameters as additional parameters in the First Stage Assessment Method will contribute to a more accurate prediction of the riskiness of the method. For this purpose, the importance of concrete compressive strength value, tensile strength value of reinforcement and whether the reinforcement bars are ribbed or not, compared to the other parameters included in the First Stage Assessment Method and whether they can be effective parameters in the rapid screening score were investigated.

2 Literature survey

The "Standard for Seismic Safety Evaluation and Guideline for Retrofitting of Existing R/C Buildings" regulation issued by the Japan Building Disaster Prevention Association (JBDPA) in 1977 was discovered after the first application of quick screening methods [2]. In 1988, FEMA 154-ATC-21. and FEMA 155-ATC-21-1. documents prepared by ATC (Applied Technology Council) and put into effect by FEMA (Federal Emergency Management Agency) also provided a serious introduction of rapid screening into the literature. These regulations were updated in 2002 and 2015 and Rapid Visual Screening of Buildings for Potential Seismic Hazards: A handbook, was published. [3],[4]. In 1993, National Research Council, Canada Seismic Screening Method [5] is included as another preliminary evaluation method of the building.

When the studies on rapid assessment in Turkey are examined, it is determined that rapid screening studies were first started to be evaluated after the 1992 Erzincan earthquake. However, the first large-scale study was *"The Study on A Disaster Prevention/Mitigation Basic Plan in Istanbul Including Micro zonation in The Republic of Turkey"*, also known as the JICA report. This study was commissioned by the Government of the Republic of Turkey to the Japanese Government in response to the significant seismic events that transpired in 1999. It was undertaken and compiled by the Japan International Cooperation Agency (JICA) at the behest of this request [6].In this study, damage estimation was carried out on a neighbourhood basis. The physical characteristics to be considered in the process of building screening from the street formed the basis and starting point of the Stage 1 evaluation methods in the Annex 2: Guidelines for the Assessment of Buildings Under High Risk [7]. "Earthquake Risk Analysis of Istanbul Metropolitan Area" study was carried out by Kandilli Observatory, Earthquake Research Institute, Department of Earthquake Engineering [8]. The purpose of this study is to develop a risk model for Istanbul by predicting the hazard assessment for the predicted scenario earthquake, predicting building damages, losses, damages to infrastructure and lifelines. Within the scope of the study, damage estimation methodology was developed based on the "Displacement Coefficient Method" given in FEMA-356 (2000) [9]. This method is also named as KOERI-Loss Method in the literature.

In addition to these, a rapid screening method also known as P25 method is proposed. In this method, a total of seven collapse scores that consider the different collapse modes of the building are calculated together with the basic structural score P1, which is calculated based on parameters such as existing column, shear wall and infill wall dimensions, stiffnesses, structural system layout, building height, various structural irregularities defined in the regulation, material and soil properties [10]. In addition, alternative rapid screening methods have been proposed for reinforced concrete and masonry buildings with the master's theses named "Development of an Alternative Rapid Screening Method to Determine the Risk Level of Reinforced Concrete Buildings" [11] and "Development of Alternative Rapid Screening Method to Determine Regional Risk Distribution of Masonry Buildings" [12]. In a study published in 2019 called PERA Method 2014 (Performance Based Rapid Seismic Assessment) [13]. In this method, an evaluation method was developed to determine the ratio of the base shear force resulting from the ground acceleration acting on the building subject to the investigation to the base shear force that it should meet according to the Turkish Building Earthquake Code [14] and to assign this value to the structure over 100 base scores.

3 Material and method

The main purpose of this study is to evaluate the performance of the rapid screening application in the "Simplified Methods that can be used to Determine the Regional Earthquake Risk Distribution of Buildings" section of the Regulation on

Principles for the Identification of Risky Structures. In addition, the evaluation criteria in the method were examined within the scope of the study. The contributions of concrete compressive strength, reinforcement type and building age, which are effective parameters for the risky or non-risk status of buildings, to the performance of the rapid screening method were evaluated.

In this context, the Risky Building database of the Ministry of Environment, Urbanization and Climate Change was utilized. This database contains detailed static analyses within the scope of the "Regulation on the Principles Regarding the Assessment of Buildings at High Risk" [1] for buildings that are determined to be risky or not risky by performing detailed static analyses within the scope of the mentioned regulation. In addition, this database contains photographs of the analysed buildings, risky - non-risk results and other information required for fast scanning. Using the Risky Building Database, a database of 402 buildings, including risky and non-risk buildings, was created after the analysis. These buildings were then scored with the "First Stage Evaluation Method" and their score status was examined according to their risky - non-risk status in detailed analysis. In the first stage evaluation method, there is no information that buildings below a certain score will be classified as risky buildings. It is only stated that the performance scores determined because of the application of the method to the buildings in the examined region can be ranked from large to small and the risk priority between the regions can be determined. For this reason, studies in the literature were utilized in determining the lower score of the riskiness limit in the rapid screening method.

3.1 Implementation of "First Stage Evaluation Method"

The working principle of the First Stage Evaluation Method is to determine the "Building Performance Score" by using the base score determined according to the "Hazard Zone" in which the building is located, the "Structural System Score" which depends on the presence or absence of Shear Wall in the load bearing system and other parameters. The parameters used in this method and the scoring of these parameters are given below.

Load-bearing system type: The structural system of the building is determined according to the vertical load resisting members (column or shear wall with/without column).

Number of stories: It is determined by counting the number of stories above the ground. Basements and lofts are also included in the number of floors.

Current situation and appearance: This parameter is reflecting the quality of materials and workmanship and the maintaining of the building. This parameter is valuated for three situations as good, average, and bad.

Soft storey: For commercial use, generally brick core walls are not constructed at ground floors of the buildings. Therefore, the ground floors of such buildings become weaker than upper floors' lateral storey deflections. This parameter is determined observationally by depending on the difference of storey heights in the building or by considering of the distinct stiffness difference between floors.

Vertical irregularity: Columns and - or shear walls that do not continue through all floors are considered as vertical irregularities.

Overhang: The differences between the floor plan area sitting on the ground and the upper floors are defined as Overhang.

Plan irregularities: The building plan may be geometrically symmetrical, or the vertical structural elements may be arranged irregularly. Plan irregularities in buildings that may cause torsion during an earthquake are taken into consideration.

Short column effect: Due to the architectural and aesthetic concerns of the columns or the improper structural system arrangement, a certain section of the column is freed, and the remaining part is rigidized in such a way that it prevents drifting, the free part of this column is exposed to much more shear force than designed. This situation is called short column effect. Generally, to provide functions such as lighting, ventilation and air conditioning on the outer walls of the basement or ground floors, the infill walls are built at different heights and band (strip) windows are formed.

Position of neighbouring slabs (Hammering effect): Buildings that are located adjacent to each other can damage each other due to collisions in earthquake shaking. If the height levels of the floors of the buildings are different from each other, this negativity increases because of the slab element breaking the vertical bearing elements of the neighbouring building. Also, the situation of adjacent buildings being evaluated at the edge or in the middle is also important in terms of the damage of the buildings in the earthquake.

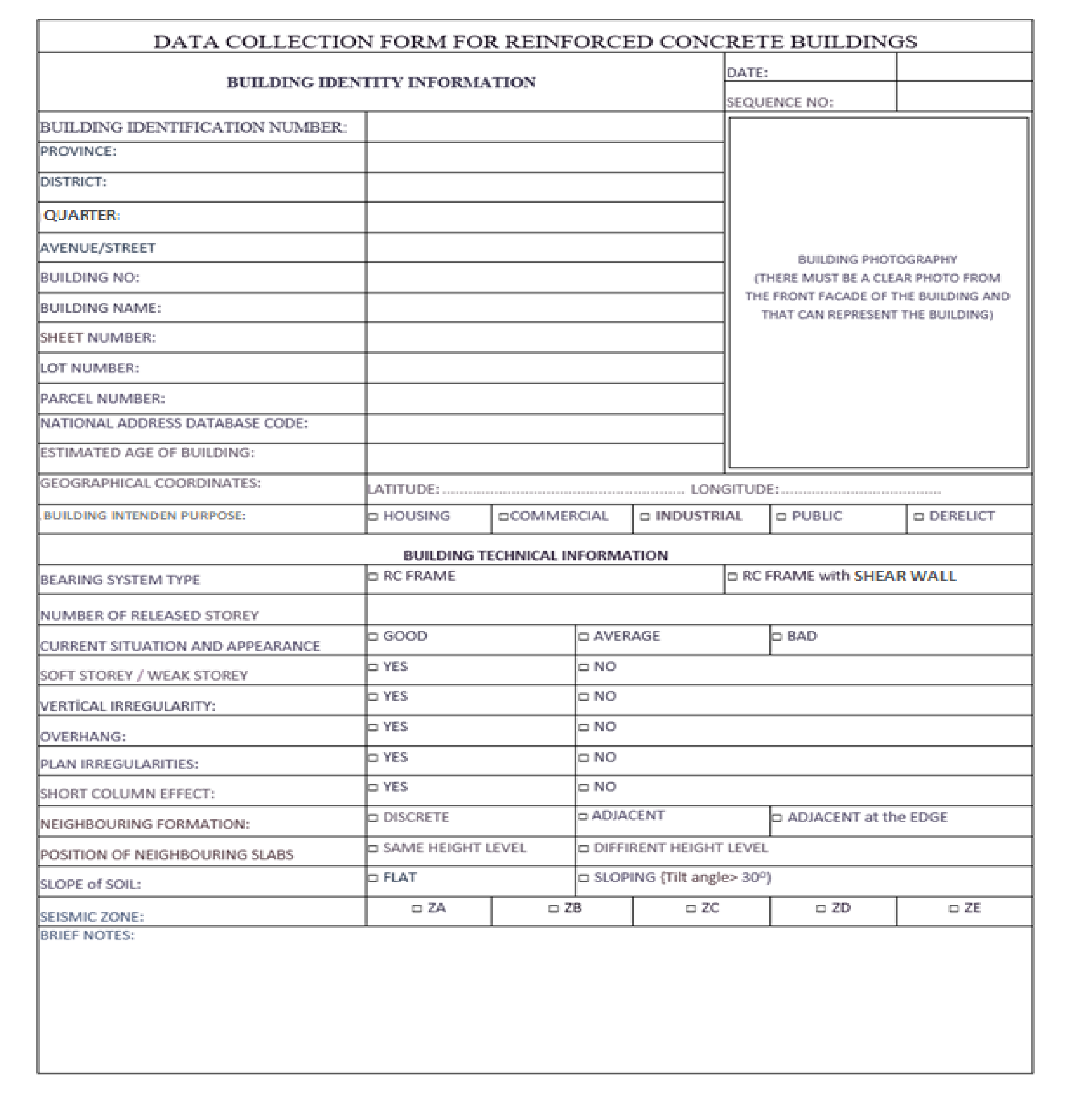
Slope of the Soil: This parameter will be determined according to whether the examined buildings are built on slopes above a certain slope.

Seismic zone: This parameter is determined as shown in the Table 1 below using the S_s coefficient which obtained by using Türkiye Earthquake Hazard Map depending on the building coordinate and the S_{DS} coefficients to be obtained with the soil class data.

In the "First Stage Evaluation Method", information is collected from the buildings using the form in Figure 1 below. Based on the collected information, the performance scores of reinforced concrete buildings are calculated based on parameters reflecting the earthquake hazard of the location of the buildings and the existing building characteristics [1].

Table 1. Earthquake hazard zones.

Seismic zone	S_{DS}	Soil type
I	$S_{DS} \geq 1.0$	ZC/ZD/ZE
II	$S_{DS} \geq 1.0$	ZA/ZB
	$1.0 \geq S_{DS} \geq 0.75$	ZC/ZD/ZE
III	$1.0 \geq S_{DS} \geq 0.75$	ZA/ZB
	$0.75 \geq S_{DS} \geq 0.50$	ZC/ZD/ZE
IV	$0.75 \geq S_{DS} \geq 0.50$	ZA/ZB
	$0.50 \geq S_{DS}$	All types of soil



DATA COLLECTION FORM FOR REINFORCED CONCRETE BUILDINGS					
BUILDING IDENTITY INFORMATION				DATE:	
				SEQUENCE NO:	
BUILDING IDENTIFICATION NUMBER:				BUILDING PHOTOGRAPHY (THERE MUST BE A CLEAR PHOTO FROM THE FRONT FACADE OF THE BUILDING AND THAT CAN REPRESENT THE BUILDING)	
PROVINCE:					
DISTRICT:					
QUARTER:					
AVENUE/STREET					
BUILDING NO:					
BUILDING NAME:					
SHEET NUMBER:					
LOT NUMBER:					
PARCEL NUMBER:					
NATIONAL ADDRESS DATABASE CODE:					
ESTIMATED AGE OF BUILDING:					
GEOGRAPHICAL COORDINATES:	LATITUDE:.................... LONGITUDE:....................				
BUILDING INTENDEN PURPOSE:	☐ HOUSING	☐COMMERCIAL	☐ INDUSTRIAL	☐ PUBLIC	☐ DERELICT
BUILDING TECHNICAL INFORMATION					
BEARING SYSTEM TYPE	☐ RC FRAME			☐ RC FRAME with SHEAR WALL	
NUMBER OF RELEASED STOREY					
CURRENT SITUATION AND APPEARANCE	☐ GOOD	☐ AVERAGE		☐ BAD	
SOFT STOREY / WEAK STOREY	☐ YES	☐ NO			
VERTİCAL IRREGULARITY:	☐ YES	☐ NO			
OVERHANG:	☐ YES	☐ NO			
PLAN IRREGULARITIES:	☐ YES	☐ NO			
SHORT COLUMN EFFECT:	☐ YES	☐ NO			
NEIGHBOURING FORMATION:	☐ DISCRETE	☐ ADJACENT		☐ ADJACENT at the EDGE	
POSITION OF NEIGHBOURING SLABS	☐ SAME HEIGHT LEVEL	☐ DIFFIRENT HEIGHT LEVEL			
SLOPE of SOIL:	☐ FLAT	☐ SLOPING (Tilt angle> 30°)			
SEISMIC ZONE:	☐ ZA	☐ ZB	☐ ZC	☐ ZD	☐ ZE
BRIEF NOTES:					

Figure 1. Rapid screening form for first-stage evaluation method.

*I*n the application of the First Stage Evaluation Method, the hazard zone of the building is determined according to the earthquake zone and soil class of the investigated area and the Base Score is determined according to the number of storeys. The Structural System Score is determined according to the load bearing system type and number of storeys. According to the Regulation, the Building Performance Score is determined by the equation shown below.

$$PP = TP + \sum (Oi * OPi) + YSP \quad (1)$$

In the equation, "PP" represents the performance score, "TP" represents the base score shown on Table 2. “Earthquake Hazard Zone” in Table 2 is determined by using Table 3 according to S_{ds} and soil class parameters. “Oi” indicates the presence of each negative parameter and is scored as shown in Table 4. “OPi” indicates the adverse parameter score and is scored according to the number of storeys of the building and the presence of the adverse conditions specified in Table 5.

Table 2. Base Scores and Structural System Scores according to hazard zone and load bearing members.

Number of storeys	Base Scores				Structural system Scores	
	Hazard zone				Load bearing members	
	I	II	III	IV	Only column	Shear wall ± column
1 - 2	90	120	160	195	0	100
3	80	100	140	170	0	85
4	70	90	130	160	0	75
5	60	80	110	135	0	65
6 - 7	50	65	90	110	0	55

Table 3. Numerical representation of soil types.

Hazard zone	S_{ds} values in TEC 2018	Soil class in TEC 2018
1	S_{ds}≥1.0	ZC/ZD/ZE
2	S_{ds}≥1.0	ZA/ZB
	1.0≥S_{ds}≥0.75	ZC/ZD/ZE
3	1.0≥S_{ds}≥0.75	ZA/ZB
	0.75≥S_{ds}≥0.50	ZC/ZD/ZE
4	0.75≥S_{ds}≥0.50	ZA/ZB
	0.50≥S_{ds}	All soil class

Table 4. Numerical representation of adverse parameters.

	Parameters	Case 1		Case 2	
		Condition	Value	Condition	Value
1	Soft Storey	None	0	Exist	1
2	Overhang	None	0	Exist	1
3	Appearance	Good	0	Average (bad)	1 (2)
4	Short column	None	0	Exist	1
5	Slope	None	0	Exist	1
6	Plan irregularity	None	0	Exist	1

Table 5. Penalty scores of the parameters

Number of storeys	Soft storey	Appearance	Overhang	Position of Neighbouring Slabs / Settlement of the building: Non-levelled, Middle	Non-levelled, Edge	Levelled, Middle	Levelled, Edge	Vertical Irregularity	Plan Irregularities	Short Column	Slope
1,2	-10	-10	-10	0	-10	-5	-15	-5	-5	-5	-3
3	-20	-10	-20	0	-10	-5	-15	-10	-10	-5	-3
4	-30	-15	-30	0	-10	-5	-15	-15	-10	-5	-3
5	-30	-25	-30	0	-10	-5	-15	-15	-10	-5	-3
6,7	-30	-30	-30	0	-10	-5	-15	-15	-10	-5	-3

3.2 Determining performance of "First Stage Evaluation Method" and upgrading offers

First Stage Evaluation Method does not directly determine the risky or non-risk status of the examined building. With this method, only the performance scores of the buildings in the analysed region can be ranked in descending order to determine the risk priority between regions. This is a major drawback for the First Stage Evaluation Method. With the literature review, studies on the determination of the lower score of the riskiness limit in the First Stage Evaluation Method have been examined.

The Ministry of Environment, Urbanization and Climate Change has determined the status of some areas identified in Istanbul - Beyoğlu and Nigde - City Centre regions, and the declaration of risky areas has been carried out in these regions. First Stage Evaluation Method was applied for 1613 reinforced concrete buildings in both Istanbul and Nigde provinces. Detailed risk building static analysis was carried out for 121 buildings selected among the buildings whose performance scores were determined. 94 of these buildings were determined as risky buildings because of static analysis. In the master's thesis prepared by Tozlu using the data provided for the declaration of risky area, it was determined that reinforced concrete buildings with a performance score below 60 points should be considered as risky buildings and should be prioritized in the urban transformation project [15], [16].

Within the scope of this study titled as "Evaluation of Rapid Screening Parameters and Suggestions for Urban Transformation of Reinforced Concrete Buildings", buildings with a score below 60 points from the buildings to which First Stage Evaluation Method was applied were evaluated as risky buildings. Within the scope of detailed static analyses in the Regulation on Principles Regarding the Determination of Risky Buildings, a building is determined as risky according to the axial compressive stress, storey shear force ratios and (⍰/h) relative storey drift values. When the risky building analysis data were examined, it was determined that the buildings were classified as risky due to the relative story drift values exceeding the limit values. In this study, graphs were drawn for Rapid Screening Scores vs Relative Storey Drift values. In the graphs, blue coloured dots indicate risky buildings, and green dots indicate non-risky buildings according to detailed statical analysis.

Firstly, in the studies carried out for Istanbul - Beyoğlu and Nigde-City Centre risky area zones, databases of 94 buildings identified as risky because of detailed analysis were obtained and the performance scores of these buildings were determined according to the First Stage Evaluation Method. When the Performance Scores of these buildings were analysed, it was observed that 57 of the 94 risky buildings received a performance score of 60 or less (Figure 2). From this point of view, it is observed that the current rapid screening scores provide 60% accurate results for risky buildings. 60% success rate is a very insufficient success rate in terms of deciding the riskiness of a building.

To increase the correct estimation rate of the " First-stage Evaluation Method " it was thought that it would be appropriate to add the "building age" parameter to the existing parameters and exclude the "building visual quality" parameter from the scoring. To increase the correct prediction rate of the "First Stage Assessment Method", it was considered to add the "building age" parameter to the existing parameters and to remove the "building visual quality" parameter from the scoring. This new updated scoring system was analysed with STATA statistical analyse software and the effect coefficients of the parameters were determined.

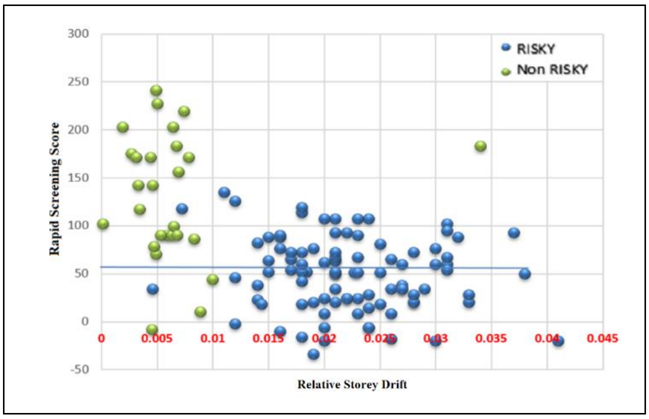


Figure 2. Rapid screening scores vs. relative storey drifts graph.

In the Risky Building database obtained from the Ministry of Environment, Urbanization and Climate Change and created specifically for this study; Reinforcement Corrosion, Stirrup Hooks Existence, Stirrup Hugging Length, Reinforcement type, Concrete Compressive Strength parameters were also taken into consideration in addition to the parameters in the "First Stage Evaluation Method". In the database created, all data were reduced to 0-1 and then multiple regression was performed by using SPSS statistical analyse software. Below, Table 6 summarizes the results of the Multiple regression analysis and Table 7 shows the standard deviations of the Regression Residual Sum. Table 8 summarizes the results.

When the results are analysed, the correlation coefficient is calculated as R=0.754. According to this value, it shows that there is a 75.4% correlation in absolute value between the input parameters used in the analysis and the risky-non risky buildings according to the detailed static analysis. Previous studies have found that a score of 60 and below in the first stage assessment method may be risky. In the process of updating the parameters and scoring, it was evaluated that a cut-off score of 0 (zero) would be more appropriate.

Table 6. Multiple regression analysis result.

Parameter	Impact Coefficients	100 x Impact Coefficients
Appearance	-0,46	-46
Number of storeys	-0,274	-27,4
Plan Irregularities	-0,193	-19,3
Building Age	-0,188	-18,8
Short Column	-0,159	-15,9
Position of Neighbouring Slabs Settlement of the building	-0,146	-14,6
Overhang	-0,092	-9,2
Reinforcement Corrosion	-0,036	-3,6
Vertical Irregularity	0,011	1,1
Soft Storey	0,022	2,2
Soil Type	0,061	6,1
Structural System Type (Only Column / Sherwall)	0,082	8,2
Existence of Stirrup Hook	0,095	9,5
Slope of Soil	0,145	14,5
Stirrup Hugging Length	0,173	17,3
Slab Level Condition on Adjacent Floors	0,173	17,3
Reinforcement Type (S220 – S420 – Other)	0,265	26,5
Earthquake Hazard Zone	0,298	29,8
Concrete Compressive Strength	0,374	37,4

Table 7. Summary of SPSS multiple regression model results.

Model	R	R^2	Adjusted R^2	Std. Estimated Error
Regression Residual Sum	0.754[a]	0.568	0.547	0.337

Table 8. Results of SPSS multiple regression.

Model	Sum of Squares	d_f	Mean Square	F	Sig.
Regression Residual Sum	56.950 43.299 100.249	19 381 400	2.997 0.114	26.375	0.000[b]

Accordingly, Base Score values are updated as shown in Table 9 and updated parameters and penalty scores according to SPSS and Stata analyses are shown in Table 10. The penalty scores were updated by considering of effects of the rapid assessment parameters on the riskiness status. Through the experiments, it was determined that applying the building age parameter as a penalty of (-5) for each year would be the most appropriate value to obtain accurate results. It is considered to create a simpler scoring system by applying penalty scores independently of the number of storeys and it was determined that the penalty scores would not have a serious effect on the results after updated penalty scores according to the analysis.

Table 9. Updated base scores and structural system scores according to hazard zone and load bearing members.

Number of storeys	Base Scores				Structural system Scores	
					Load bearing members	
	Hazard zone				Only column	Shear wall ± column
	I	II	III	IV		
1 - 2	35	60	100	135	0	100
3	25	40	80	110	0	85
4	15	30	70	100	0	75
5	10	25	50	75	0	65
6 - 7	0	10	30	60	0	55

Table 10. Updated rapid screening parameters and penalty scores.

Soft storey	Exist: -20	Absent: 0
Overhang	Exist: -20	Absent: 0
Plan Irreg.	Exist: -10	Absent: 0
Short Column	Exist: -30	Absent: 0
Slope of Soil	Exist: -5	Absent: 0
Building Settlement	Adjacent: Position of Neighbouring Slabs	Discrete: +20 Non-Levelled: 0 Levelled: -20
	Building Position	Middle: 0 Edge: -10
Building Age		Building Age x (-5):

In the scoring using the updated Rapid Assessment Method, the rate of correctly estimating the riskiness of buildings was calculated as 82%. This scoring system is named as "Building Score (SS)" method. While the correct estimation rate was 60% in the First Stage Evaluation Method in the current regulation, this rate reached 82% with this new method (Figure 3).

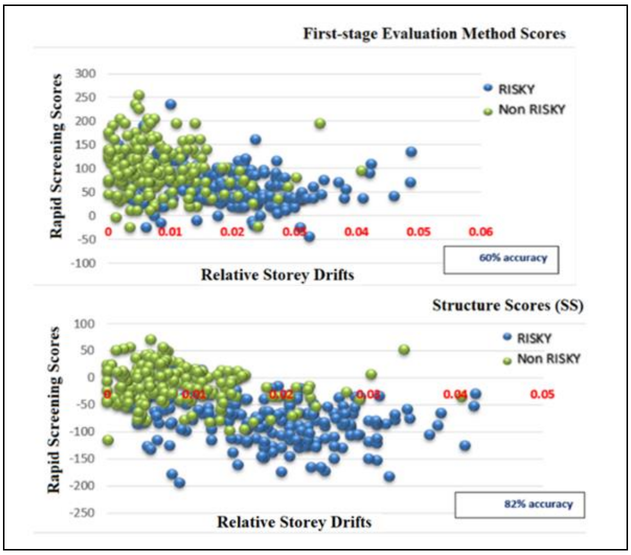


Figure 3. Comparison of the structure score method and the first-stage valuation method.

4 Research findings

"Building visual quality" is a relative concept and may vary from person to person. A building gained a good appearance by visual modifications, sheathing, repairing etc. may have a very inadequate load bearing performance. Accordingly, it would be appropriate to remove the "building visual quality" parameter. When the detailed analysis data were examined, it was determined that the concrete compressive strength value was lower than 15 (MPa) and flat reinforcement was used in most of the buildings identified as risky. Instead of using the apparent quality parameter, it is considered to use the building age parameter, which is associated with concrete compressive strength and steel grade.

4.1 The relationship of the building age with the Reinforcement type and the effect of the Reinforcement type on the building risk status

In the database consisting of 402 reinforced concrete buildings and specially prepared for this study, the relationship between building age and reinforcement type was specifically analysed (Figure 4 and Table 11). In this analysis, it is observed that the type of reinforcement is related to the age of the building, flat bar (S220) reinforcement is generally used in buildings built in 1997 and before. Also, all the buildings using ribbed bar reinforcement in the database are determined as non-risky.

Table 11. Reinforcement type - risk distribution.

R. Class	Non-Risky	Risky
S220 (Flat)	98	198
S420 (Ribbed)	103	3

4.2 Effect of concrete compressive strength on the building risk status

When the relative storey drift vs. concrete strength examines for 402 buildings in the database, it is observed that as the concrete strength decrease, storey drifts increase. When the concrete compressive strength is 15 MPa or higher, the probability of the examined building being risky is reduced. Upon evaluating the concrete compressive strengths of the 402 buildings within the database, it becomes evident that a predominant number of the structures built prior to the year 1999 exhibit compressive strength values that reside below the 15 megapascal (MPa) threshold, as visually depicted in Figure 5.

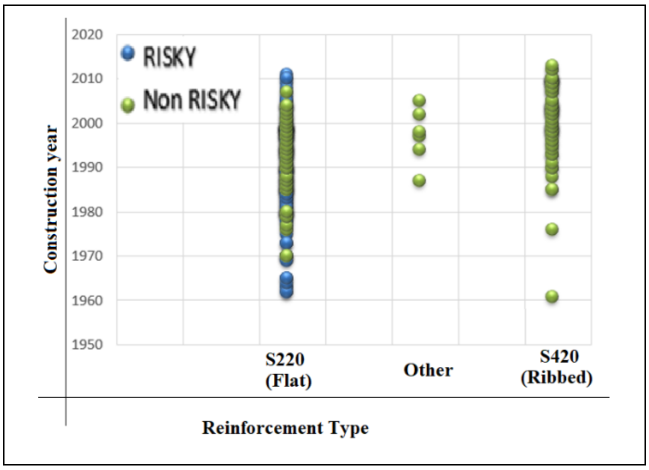


Figure 4. Construction year vs. reinforcement type graph.

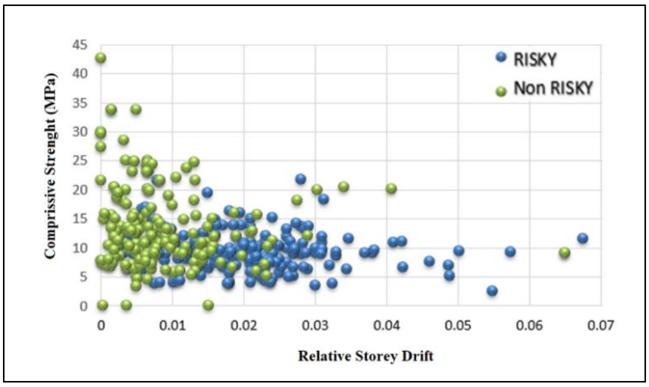


Figure 5. Concrete compressive strength-storey drift relationship.

4.3 Effect of building age on building risk status

When the tensile strength of reinforcement and compressive strength of concrete parameters were analysed, it was observed that these two parameters were effective in risky conditions of the structures; however, the use of these parameters would not be applicable for rapid screening methods using properties that can be determined observationally. For the determination of concrete compressive strength, since the core method is not applicable for rapid screening, the use of test hammer and ultrasound methods can be recommended. However, considering the viability and application time of the rapid screening method, it is thought that the "building age" parameter indirectly reflects the properties of reinforcement tensile strength and concrete compressive strength in the scoring, and it would be appropriate to use the "building age" parameter instead of these two parameters.

To examine the relationship between the risky status of the buildings in the database of the Ministry of Environment and Urbanization and the age of the building, the "building age" parameter was added to the quick scan parameters and the results are shown in the graph in Figure 6. It is concluded that the addition of the "building age" parameter makes it easier to distinguish between risky and non-risk buildings, and therefore the addition of building age to the rapid screening method will contribute to the accurate results of the method.

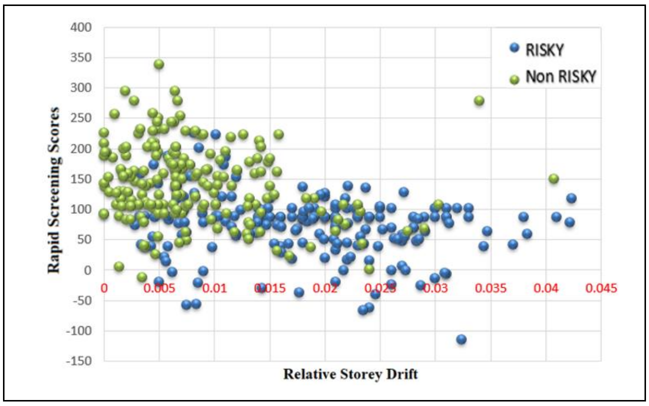


Figure 6. Rapid screening results after adding the building age parameter.

4.4 Interpreting building age with SPSS statistical analysis

By applying normalization to the data obtained from the Ministry of Environment and Urbanization, multiple regression was applied for Reinforcement type, concrete strength, and seismic zone parameters with the SPSS statistical analysis program. As a result of the analysis, the following results (Table 12) have emerged.

Table 12. Summary of SPSS multiple regression analysis results according to reinforcement type, concrete compressive strength, and seismic zone parameters.

Parameters	Impact Coefficients	100 x Impact Coefficients
Reinforcement type	0.265	26.5
Concrete Compressive Strength	0.374	37.4
Seismic Zone	0.298	29.8

The parameters used in this updated Rapid Screening Method and the scoring of the parameters have been updated as shown in Table 10. These parameters were analysed in the STATA and SPSS statistical analysis program and their effects on the riskiness of the buildings were determined. Thereupon, the contribution of reinforcement type, concrete strength, and earthquake zone parameters to the correct estimation of the method was examined. According to the results, it was predicted that integrating the reinforcement type and concrete strength parameters into the this updated Rapid Screening Method would be appropriate. In this case, since it is not possible to determine the concrete compressive strength value accurately without taking the core and the coring process is a rather slow process for the rapid evaluation method, only the reinforcement type parameter would be appropriate to use in the suggested Rapid Screening Method was concluded.

Since destructive methods will have to be used in determining the Reinforcement type, it was thought that it would be more appropriate to reflect this parameter to the scoring indirectly by associating it with the building age parameter in terms of the fastness and easy applicability of the method.

5 Conclusions

In this study, the parameters in the "First-stage Evaluation Method" in the literature were examined with the SPSS statistical analysis program, and their compliance with the detailed analysis results and their contribution to this compliance were tried to be determined. First, the connections between the building age and the Reinforcement type were evaluated, and it was observed that the buildings built before 1997 were generally used with plain bar reinforcement. It has been understood that the plain bar reinforcement is also an effective parameter in determining the buildings as risky as a result of analysis.

The contribution of the "building age" parameter to the accuracy of the method was determined using SPSS statistical analysis programs and compared with other parameters. It was determined that the "building age" data is one of the most important parameters in whether the building is risky or not.

It is concluded that the addition of the "building age" parameter to the evaluation method included in the "Principles for Determining Risky Buildings" may be effective in increasing the accuracy of this method.

In addition, it is considered appropriate to exclude the "building visual quality" parameter from the method on the grounds that it may vary according to the view scores of the technical staff making the scoring.

6 Author contribution statements

In the study carried out, Emrah BAHSI under the titles of formation of the idea, determination of the process to be carried out, literature review and interpretation of the results; Onur COSKUN under the titles of application of methodology, literature review and interpretation of results; Omar Faruk CINAR contributed to the literature review, interpretation of the results, writing and content control of the manuscript, database creation and data synthesis, statistical analysis.

7 Ethics committee approval and conflict of interest statement

"There is no need to obtain permission from the ethics committee for the article prepared".

"There is no conflict of interest with any person / institution in the article prepared".

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