STRUCTURAL HEALTH MONITORING OF STEEL AND COMPOSITE BRIDGES IN RUDBAR-MANJIL REGION IN IRAN

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ABSTRACT: Iran is located in a seismic prone region and in every year, several earthquakes happen that cause severe damages. Guilan province is located in the north of Iran. High seismic activity of this region, especially Rudbar-Manjil region needed to regular inspection of infrastructure and bridges. Visual inspection and structural health monitoring is an engineering tool that is used for control the changing of condition that gives good information for management, decision and revise codes. In this paper structural health monitoring of six steel and composite bridges in Rudbar-Manjil region are studied and existing condition related to main component are investigated and needing bridges for rehabilitation and retrofit are discussed based on a visual method.

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1 INTRODUCTION

Lifelines and infrastructure have an important role in every country and annually a huge budget allocate to the maintenance and rehabilitation of these structures.. Bridges, as an infrastructure that connect the cities are important from political, economical and social point of view. Rudbar is one of important city that connect the north of Iran, Guilan province to the capital and the other part of Iran. Therefore, there are some important bridges in this region that sustain heavy track loads and passing rate of cars on these bridges is significantly increased in recent years. This is because of construction new high way and free way between Guilan and Qazvin provinces that passes through Rudbar and Manjil as an important free way that for transferring goods to industrial towns and capital. Transportation and goods trade to neighbourhood provinces made Guilan's roads and bridges as vital arteries in economical and political point of view. Management of bridges in the recent years has improved significantly. Using new methods and technology, such as wireless or fiber optic sensor and remote management changed infrastructures management significantly.

Today's most of decisions are based on visual inspection of projects that give good information and vision to engineer for choosing the best method for maintenance and rehabilitation of mega structures. Using some new methods such as signal processing, image processing, neural network and fuzzy logic etc can help to engineer to have a better view of structures and assess the condition of structures precisely and verify the assumptions in codes and control design, construct or service period. Several researchers study using non-destructive test method [Thakkar et al].

Also, a system of classification for damage detection, is investigated [Rytter], a finite-element model to identify structural parameters and mechanisms has been studied [Brownjohn]. In Irvine, California, the Jamboree Road over-crossing bridge is instrumented for performance monitoring purpose [Kim].In this paper, fast assessing of six steel and composite bridges(figure1 and 2) in Rudbar-Manjil has been investigated. Using visual inspection as the main source of relevant data to carry out the condition assessment is usual methods for structural health monitoring (SHM).

2 SEISMIC ACTIVITY OF GUILAN PROVINCE

The Manjil (a city in Guilan province) earthquake of 20 June 1990 (Ms=7.7 Richter), strongly shocked the northwestern Iranian territory that caused many destructions and human casualties. An estimated 35.000 people lost their lives and more than 300.000 were left homeless. The earthquake ground shaking caused enormous destruction of unreinforced Structures. The most parts of the imprinted great area were of western high Alborz and Tarom district. The amount of damage in rural areas was very extensive that resulting in the destruction of about 1100 villages [Sartipi]. Seismic hazard assessment of Guilan Province including Manjil in Iran has been studied and shown(figure3), with respect to historical earthquakes in the region of Guilan province and existing active faults like Manjil-Rudbar, this region has high seismic [Ghodrati et al] and liquefaction potential [Ycgian et al].

Figure1.Vali Abad Bridge(left), Connection in Ali Abad bridge(right)

Figure2. Loushan New bridge deck and expansion joint

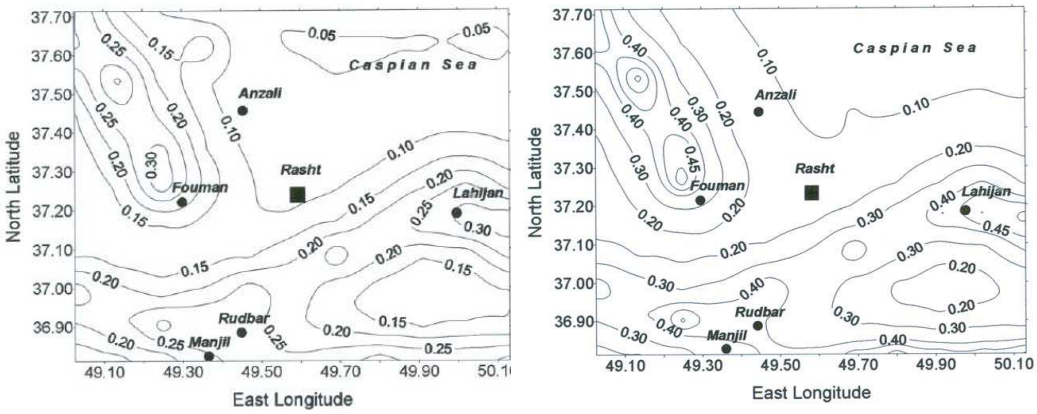

Figure3. Horizontal seismic hazard (PGA over bedrock) map of Guilan province using logic tree for 475 year return period (left), for 2475 year return period (right) [Ghodrati]

Table 1. Main faults of Guilan Province [IIEES]

No	Name	Fault Length (km)
1	Manjil-Rudbar	152
2	Talesh	75
3	Fouman	60
4	North Alborz	300
5	Khazar(Alborz)	600
6	Javaher Dasht	74
7	North Qazvin	60
8	Zardgoli	40
9	Banan	66
10	Taleghan	64

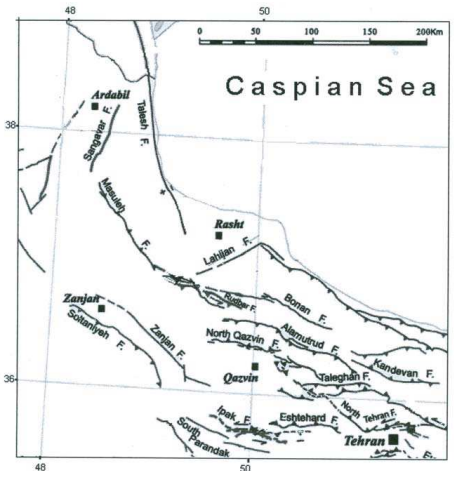

Fig4: Active faults of Guilan province and the city of Rudbar [5]

Based on Horizontal seismic hazard (PGA over bedrock) map of Guilan province for 475 and 2475-year return period (figure3), Rudbar and Manjil have a high seismic hazard. Having 152 km Manjil-Rudbar fault in this region show high seismic potential of this region(Figure4). Beside high seismic activity and hazard, some cases of liquefaction have been reported during Manjil earthquake 1990 [Ycgian et al].

3 SHM PROCEDURE OF STEEL AND COMPOSITE BRIDGES

In this research, six steel and composite bridges in Rudbar-Manjil region has studied and health of all-important part of structural members are investigated and based on the existing condition, a SHM score allocated to each of bridge. Six important parameter for SHM are as deck, abutment, river engineering, middle piers, wall for water conduct. The corrosion of steel members and connection, decaying, water scour, deformed expansion joint rubber, lacking of a good cover over bridge etc had affected the performance of these bridges. The details of selected bridges are mention in table2. Most of the bridges in Guilan province are pre fabricated but the in situ welding of members were not so good and in some cases the connections need to rehabilitate or member need to be replaced with a new one. All of data explored during annually visual inspection that has been done in road and transportation office of Guilan province. It worth to say that deck of these bridges are made from steel and composite, but the piers and abutments are made with concrete.

Table 2. Name and details of selected composite and steel bridges in SHM study

No	Name of Bridge	Type of Deck	Total Length (Meter)	Total Width of Deck (Meter)	Number of span
1	Vali Abad New Bridge	composite	180	13.30	6
2	Ali Abad Bridge	Steel Truss	92	6.5	2
3	Khalil Abad Bridge	Composite	90	5.5	2
4	Doulat Abad Bridge	Steel Truss	79	2.8	2
5	Loushan Old Bridge	Composite and steel truss	42	12.45	1
6	Loushan New Bridge	composite	45	12.60	1

A visual method is used for SHM of these bridges and assumptions are as table3:

Table3. SHM score and determine the condition of bridge's health

Total health score	**Bridge condition**
0-25	Bridge is out of service and traffic must be stopped
25-50	Traffic is limited and an immediately rehabilitation should be done
50-75	Bridge needs essential repair
75-90	Bridge needs rehabilitation
90-100	Bridge is in good condition and just need to maintenance

Based on existing condition of bridges the results of SHM are summarized in table 4.

Table4. SHM score and determine existing condition of bridges

No	Inspected Member	Maximum health score based on visual inspection			Vali Abad New Bridge	Ali Abad Bridge	Khalil Abad Bridge	Doulat Abad Bridge	Loushan Old Bridge	Loushan New Bridge
		With conduct wall	Without conduct wall	Without middle piers						
1	Deck	20	23	25	21.0	18.1	17.5	17.2	21.9	20.3
2	Abutments	30	36	60	34.9	35.2	27.5	28.6	56.8	57.5
3	Middle Piers	35	35	-	35.0	32.8	30.3	35.0	0.0	0.0
4	Water conduct wall	9	-	9	-	-	8.8	-	8.2	8.1
5	Restrain	1	1	1	1.0	1.0	0.8	1.0	1.0	1.0
6	River engineering	5	5	5	5.0	3.9	4.3	4.9	4.9	5.0

As the condition of these bridges are summarized in table 4 and figure 6, deck of these bridges are not in good condition. One reason of such condition is lacking a good drainage system in bridges and surface water cannot collect and guide perfectly. In some cases the high of pipe that used for drainage system are so short to conduct the water to lower height than deck, so water pour directly on top of middle piers, abutments or deck body. Rehabilitation of asphalt over bridge changes the initial slope that designed for conducting surface water. Figure7 shows the deck of Loushan Old Bridge and Loushan New Bridge.

Filling drainage system and expansion joint with debris and lacking of seasonal cleaning plan caused the deterioration and corrosion of different part of bridges increases annually. As showed in figure 6 total visual SHM score for 2 bridges are

below than 90 and they need to rehabilitate and retrofit. This fact is so important because of high seismic potential of this region and based on some disaster in before specially 1990 earthquake. These bridges will be used as an access way to cities and helping the people easily. So, paying attention to these bridges and rehabilitation of these bridges help to having access and sending facilities to different areas of these regions.

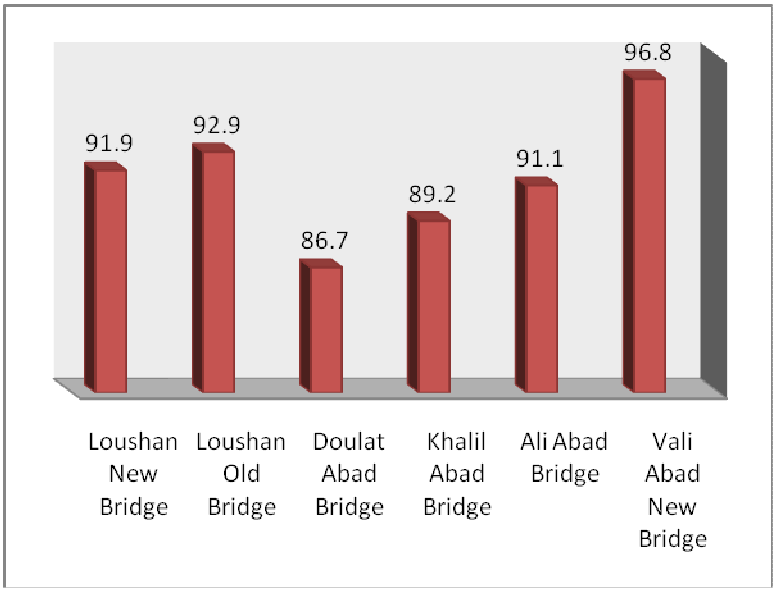

Figure5. Total SHM score of concrete bridges (out of 100) in Rudbar - Manjil Region

Figure6: Loushan Old Bridge with steel truss and composite deck (left), Loushan New Bridge with composite deck (right)

Figure 5 shows that Kahalil Abad and Doulat Abad Bridge are needed to retrofit. In these cases SHM score of middle piers and water scour of them caused some damages. Some suggestions for maintenance of these bridges are: replace short drainage pipe with some longer pipe to conduct the surface water lower than pier cap and deck. Adding some casing protection shield in abutment, embankment and middle piers that exposed to river water current will help to prevent of water scour and landslide in those areas. Changing the expansion joint rubber with some new one can help to prevent the stroke that caused by passing heavy trucks in that region.

4 CONCLUSION

In structural engineering, nothing is more important than the health of structures. Once the structure collapses, a huge loss in terms of human life and wealth can be expected. Lifelines and infrastructure have an important role in every country. As Iran is located in a seismic prone region, this issue is so important. In addition, seismic hazard assessment of Guilan Province including Manjil in Iran showed a high seismic potential in this region. In this paper, a SHM study of six steel and composite bridges based on visual inspection in Rudbar-Manjil region that included Manjil city has been done and it showed Khalil Abad and Doulat Abad bridges are needed to care and rehabilitation program. This condition aroused from corrosion of different part of bridges such as deck, piers and abutments. The necessity of rehabilitation and retrofit program of these bridges are so clear because of experience about accessing and helping the people of cities immediately after happening a disaster. Some suggestions for rehabilitation of these bridges are replacing short drainage pipe with some longer pipe to conduct the surface water lower than pier cap and deck. In addition, adding some casing protection shield in abutment, embankment and middle piers that exposed to river water current will help to prevent of water scour and landslide in those areas.

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