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BRIDGES DEFECTS AND MAINTENANCE STRATEGIES IN EGYPT

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ABSTRACT

A significant difference between essential and preventive maintenance is that essential maintenance is normally undertaken when the bridge reliability has fallen to or below the target value while preventive maintenance is undertaken when the bridge reliability is still above the target value. This paper aims to know and identify the main and minor defects in the bridge in Egypt in order to prepare corrective plan to solve these defects in preventive stage. A sample of bridges distributed overall Egypt and had different conditions will be chosen, studied and analyzed. The sample includes 45 bridge and its maintenance reports. The end result of this paper will be a general reliability –based framework to be used by General Authority for Roads & Bridges and Transportation in Egypt in order to plan optimal strategies for the maintenance of its bridge network.

1- INTRODUCTION:

Bridges are essential infrastructure of the transportation network. Therefore, maintenance tasks are mandatory to prevent these structures from degradation overtime. (Cheng & Hoang [1]). As the existing tasks of bridges continue to deteriorate, many countries have to deal with the ever increasing demands on the limited resources available for their maintenance. (Das [2]). The maintenance planning find a balance between obtained because the planning horizon spans amount of uncertainty is inherent-rating process and the cost actions (Yang et al. [3]).

The function of the road is to provide a safe, economical and effective road network for the movement of people and goods. And an effective bridge management strategy is very important in fulfilling this function. In terms of the demand of current operation and management of the existing highway bridges (Shan & Li [4]). Timely and adequate maintenance interventions are therefore crucial to ensure the functionality of existing bridges in a network. Under budget constraints, it is important to priorize maintenance needs bridges that are most significant to the functionality of the entire network. (Liu & Frangopol [5]). Bridge risk assessment often serves as the basis for bridge maintenance priority ranking and optimization and conducted periodically (Elag & Wang [6]).

2- Statistical Data:

Bridge statistics were collected from General Authority for Roads & Bridges and Transportation (GARBT [7]). Chart [1] presents the distribution of the bridges over all Egypt.

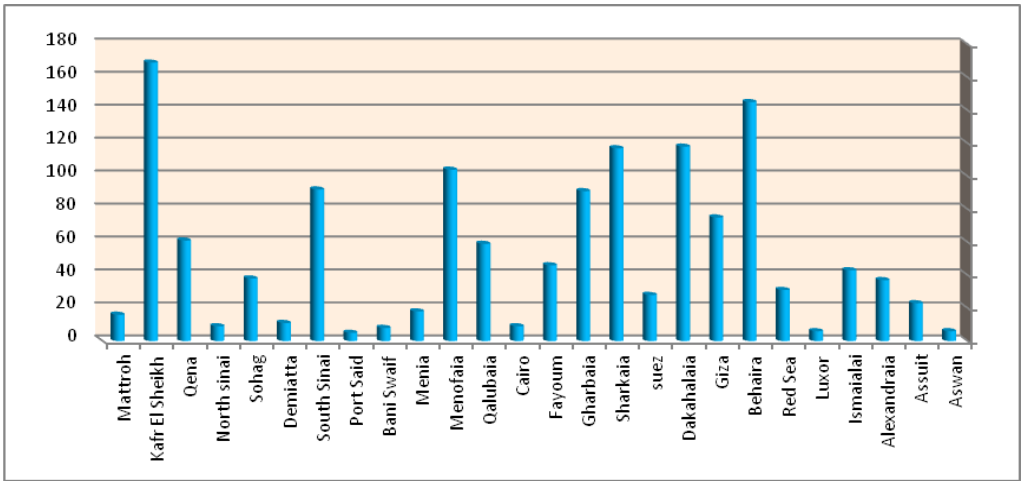


Chart [1] Bridges distribution in Egypt according to governorate

These bridges include all types of bridges fixed, movable, culverts and people bridges. This paper will classified the bridges according to the constructed year as shown in chart [2].

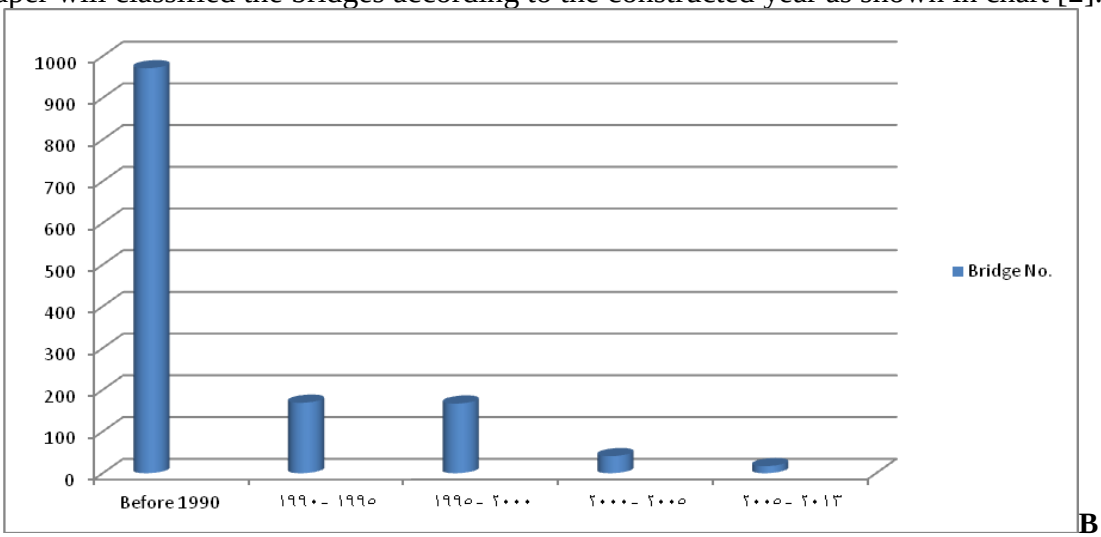


Chart [2] Bridges distribution in Egypt according to constructed year

Bridges sample

In order to know the current status for bridges maintenance in Egypt, this paper will introduce a sample of 45 bridges was selected from (GARBL [7]) inspection reports archive. The bridges in the sample had selected after meetings and discussions with bridge expertise, the sample size was calculated according to the following formula (WEBSITES [8])

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+(\frac{z^2 \times p(1-p)}{e^2 N})}$$

(WEBSITES [8])

Where:

Z : it is the number of standard deviations a given proportion is away from the mean. (1.28)

p: percentage picking a choice expressed in decimal (0.9)

e: Margin of error (5%)
N: the total number of the bridges.(1003)
The bridges in the sample will be showed in Table [1]. The sample covers all governorates in Egypt.

Table [1] Bridges sample data

S.N.	Bridge Name	Location	Bridge Description	Inspection Date
1	Zefta Bridge on rail way	Zefta	High bridge rested on two side wall – three spans	20-11-2013
2	Zefta – Met Ghamr Bridge	Zefta	High bridge, slab system & beams rested on columns	28-1-2014
3	Metobas Bridge	Kafr El Shikh	High bridge, slab system & beams rested on columns	27-1-2014
4	Usef sea Bridge	Bani Swaif	Reinforced concrete and spans 20-24 m and steel span over the sea	23-12-2013
5	Hassan Wasef Bridge	Bani Swaif	Reinforced concrete and spans 20 m and steel span over the sea	23-12-2013
6	High Assuit Bridge (on the Nile)	Assuit	Reinforced concrete and spans 25-30 m	1-11-2013
7	Menia Sandoub Bridge	Suez Canal Area	Reinforced concrete, slab and beams system rested on piles.	10-1-2013
8	El Mansoura Bridge	Mansoura	High bridge, slab system & beams rested on columns	20-1-013
9	El Wasafaia Bridge	Ismailia –Cairo Road	High bridge, slab system & beams rested on columns	25-2-2013
10	Nabaroua Bridge	Dakahlaia	High bridge, slab system & beams rested on columns	11-1-2014
11	Sakr sons Bridge	Canal / Sinai Area	Reinforced concrete, three spans, slab and beams system rested on piles.	25-2-2013
12	Sawy Bridge	Canal / Sinai Area	Reinforced concrete, three spans, slab and beams system rested on piles.	27-2-2013
13	Oil factory Bridge	Canal / Sinai Area	Reinforced concrete, three spans, slab and beams system rested on piles.	27-2-2013
14	Badawy Bridge	Canal / Sinai Area	Reinforced concrete, three spans, slab and beams system rested on piles.	2-3-2013
15	El Khadarawaya canal Bridge	Banah / Kafr El Zayat Road	Surface bridge , beam and slab system	5-1-2012
16	Saif Sea Canal Bridge	Banah / Kafr El Zayat Road	Surface bridge , beam and slab system	5-1-2012
17	Tanta Bridge	Banah / Kafr El Zayat Road	High bridge, Statically system is main beams, secondary beams and slabs.	5-1-2012
18	Toukh Bridge	Banah / Kafr El Zayat Road	Surface bridge , beam and slab system	8-1-2012
19	Kased canal Bridge	Banah / Kafr El Zayat Road	Surface over canal and has three openings. Beam system	8-1-2012
20	Qewasana Bridge	Banah / Kafr El Zayat Road	High bridge, Slabs rested on main beams and secondary beams.	8-1-2012

21	Attfa drainage Bridge	Banah / Kafr El Zayat Road	Surface bridge, Slab type	8-1-2012
22	EL Khatatba Bridge	Manashi / Khatatba Road	High bridge, seven concrete spans, Slabs rested on main and secondary beams and piles	10-12-2011
23	El Tayraya Bridge	Manashi / Khatatba Road	High bridge, seven concrete spans, Slabs rested on main and secondary beams and piles	10-12-2011
24	Kafr Dawood Bridge	Manashi / Khatatba Road	High bridge, seven concrete spans, Slabs rested on main and secondary beams and piles	15-12-2011
25	Kafr Dawood Bridge (surface)	Manashi / Khatatba Road	Surface Bridge, has three opening reinforced concrete and the middle is steel. Slabs rested on main and secondary beams	15-12-2011
26	Bollen Bridge	Manashi / Khatatba Road	High bridge, has three opening, Slabs rested on main and secondary beams	15-12-2011
27	High bridge at Kafr Dawood	Middle and West Delta	Reinforced concrete bridge. Slabs rested on main beams and secondary beams and piles.	20-5-2012
28	Lanch Bridge	Port Said	Steel structures bridge , span 20-30 m	11-7-2011
29	Canal two Bridge	Port Said	Concrete spans, Slab and beams rested on piles.	15-7-2011
30	Old El Adwa Bridge	El Menia	Six spans reinforced concrete and one steel span	10-3-2010
31	Kom Ombo Bridge	Aswan	14 concrete spans , Box section and one steel span	8-4-2010
32	Luxor Airport Bridge	Luxor	Eight concrete spans and one steel span over the railway.	23-4-2011
33	Desouk Bridge over railway	South / West Delta	High Bridge over railway, Slabs rested on main & secondary beams& columns	12-1-2012
34	Desouk Bridge over Nile	South / ``````````````West Delta	High Bridge , Box section over Nile	12-1-2012
35	South Sea Bridge	South / West Delta	One steel span rested on concrete foundation and piles	20-1-2012
36	El Shabasaia Bridge	South / West Delta	One span from reinforced concrete.	20-1-2012
37	El Awalaui drainage Bridge	South / West Delta	One span from reinforced concrete.	26-1-2012
38	Agamaia Bridge	South / West Delta	One span from reinforced concrete.	26-1-2012
39	El Farodous Bridge	Canal / Sinai	Concrete spans simple , Slabs rested on beams	18-12-2011
40	Tanata- Bassun Bridge	Tanta	One span from reinforced concrete.	10-8-2010

41	Nashard drainage Bridge	Tanta	Concrete slabs rested on beams	18-8-2010
42	Batanawaia canal Bridge	Tanta	Concrete slabs rested on beams	18-8-2010
43	Ashtom El Gameel Bridge	Port Said / Demiatta Road	Six spans, Concrete slabs rested on beams and columns rested on concrete foundation and piles	28-10-2011
44	El Sadat Bridge	Bani Swaif	Concrete slabs and steel slabs over railway	15-10-2011
45	Kilo 4.5 Bridge	Ismalaya/ Port Said Road	Six spans, Concrete slabs rested on beams and columns rested on concrete foundation and piles	20-11-2011

3- Data analysis:

After collecting the inspection reports, bridge defects will be classified according to the structural element as shown in chart [3] and it shows the percentage of the defects that was found.

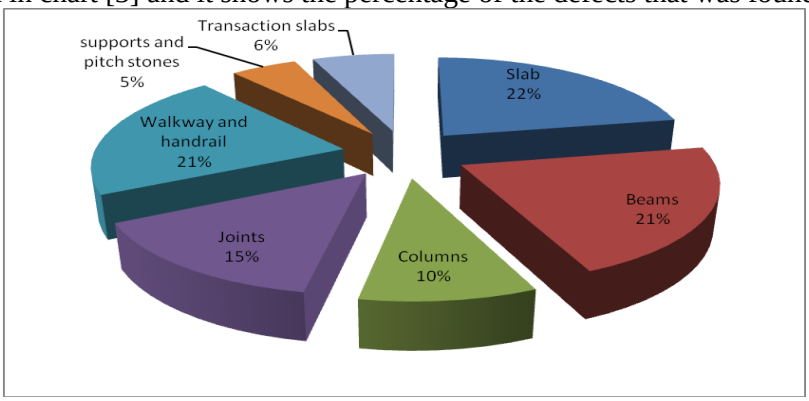


Chart [3] Bridge defects per structural element

It was clear that majority of defects concentrated in slabs, beams and walkways and handrails. The defects in joints had 15% of the bridges sample. Also columns defect was 10% of the sample. The defects in transaction slab had 6% of the bridges sample. Also supports and side pitch stones defect was 5% of the sample.

Slabs defects detailed in Table [2] and Chart [4]. The majority of defects in slabs are appearance steel bars and voids in slabs. That will cause rust in the steel bars and on the long term will decrease the strength of the reinforced concrete cross section. The lowest defects in slabs were the weakness of the concrete strength and steel bars in the cross section.

Table [2] Slabs defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Voids and cavities in slabs	24.45
2	Cracks in slabs	11.11
3	Downfall parts of the concrete slabs	17.78
4	Appearance steel bars in the slabs	24.45
5	Rust in steel bars	13.33
6	No concrete cover	24.45
7	Weakness in rebar and concrete strength	6.67
8	Separation in transaction slab	8.89

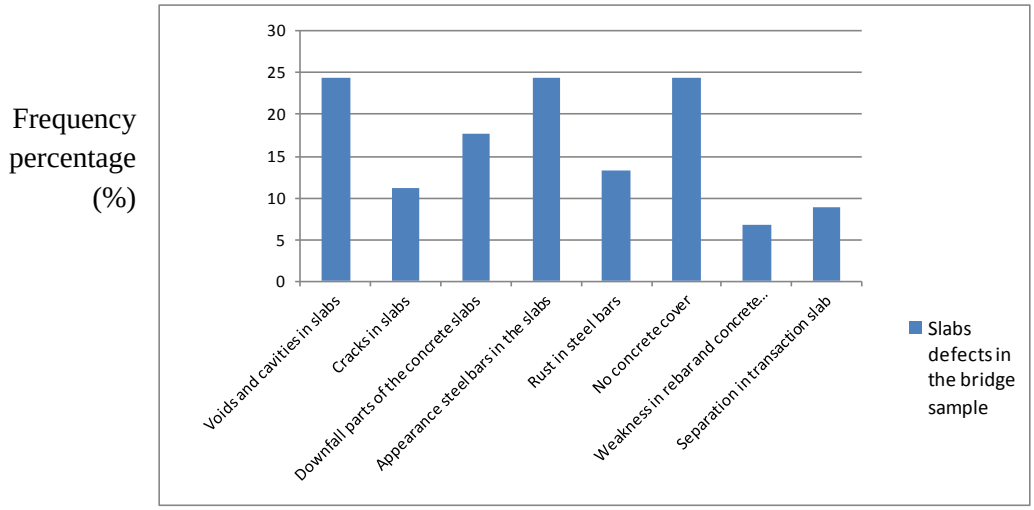


Chart [4] Slabs defects in the bridge sample

Beams defects detailed in Table [3] and Chart [5]. The majority of defects in beams are appearance rebar and voids in beams. That will cause rust in the steel bars and on long term will decrease the strength of the reinforced concrete cross section. The lowest defects in beams were the weakness of the concrete strength and steel bars in the cross section.

Table [3] Beams defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Voids and cavities in beams	31.11
2	Cracks in beams	11.11
3	Downfall parts of the concrete	6.67
4	Appearance steel bars	28.89
5	Rust in steel bars	15.56
6	No concrete cover	22.22
7	Weakness in rebar and concrete strength	6.67

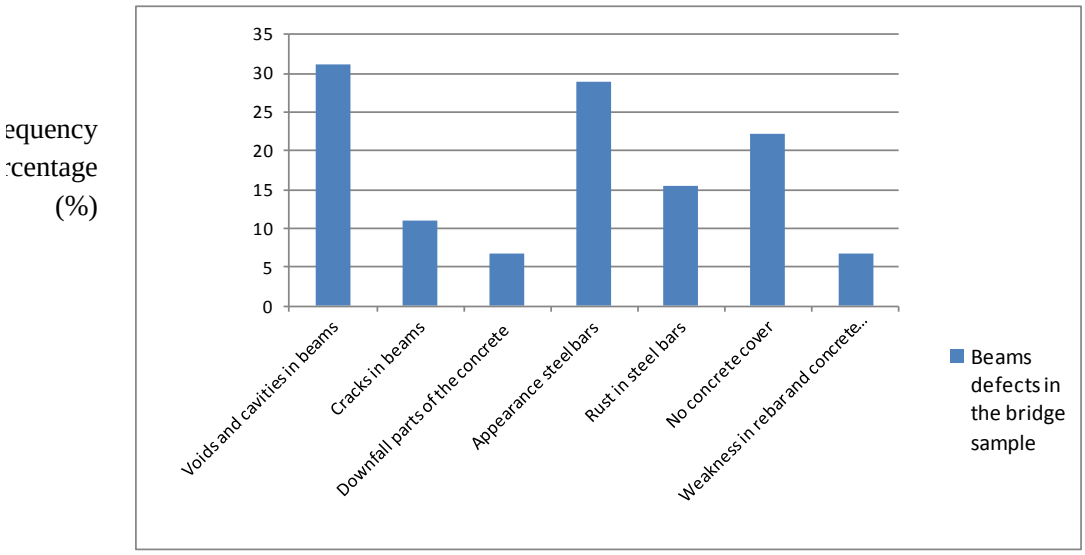


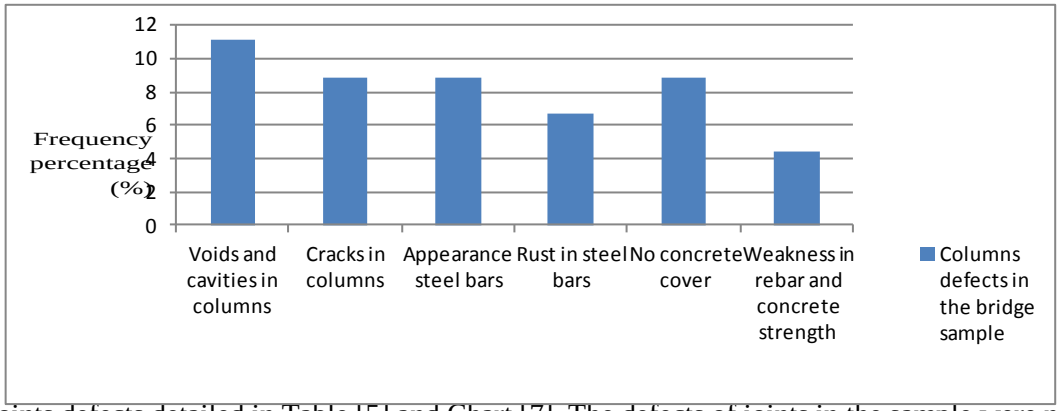
Chart [5] Beams defects in the bridge sample

Columns defects detailed in Table [4] and Chart [6]. The majority of defects in columns are voids in columns, appearance rebar and cracks in the columns. That will cause rust in the steel bars and on long term will decrease the strength of the reinforced concrete cross section. The lowest defects in columns were the weakness of the concrete strength and steel bars in the cross section.

Table [4] Columns defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Voids and cavities in columns	11.11
2	Cracks in columns	8.89
3	Appearance steel bars	8.89
3	Rust in steel bars	6.67
5	No concrete cover	8.89
6	Weakness in rebar and concrete strength	4.44

Chart [6] Columns defects in the bridge sample

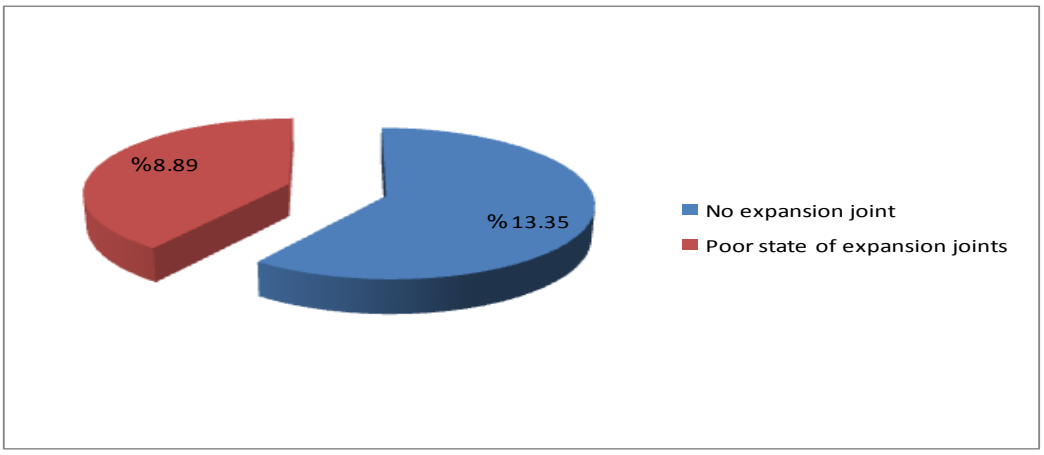


Joints defects detailed in Table [5] and Chart [7]. The defects of joints in the sample were no expansion joints in six bridges and poor status in four bridges.

Table [5] Joints defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	No expansion joint	13.35
2	Poor state of expansion joints	8.89

Chart [7] Joints defects in the bridge sample



Walkway and handrails defects will be detailed in Table [6]. The majority of defects in walkways and handrails are rust in handrail and disappear many parts of handrail. That will cause rust in the steel bars and on long term will decrease the strength of the reinforced concrete cross section. The lowest defects were Failure in handrail beams and poor condition of the middle island.

Table [6] Walkway and handrails defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Poor State of walkway	28.89
2	No walkway	15.56
3	Failure in handrail beams	2.22
4	Poor state of handrail beam and rust in rebar	31.11
5	Failure in walkway and handrail	15.56
6	Disappear many parts of handrails	37.78
7	Rust in handrail	37.78
8	Poor condition of the middle island	11.11

Supports and cladding defects will be detailed in Table [7] and Chart [8]. The majority of defects is cladding failure at bridge entrance and should be noticed during construction phase well. The minor defect is accumulation of dust and this required periodical follow up.

Table [7] Supports and cladding defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Poor state of the cladding	11.11
2	Cladding failure at bridge entrance	13.33
3	Rust in supports	8.89
4	Accumulation of dust	4.44

Transaction slab defects will be detailed in Table [8] Chart [9]. The majority of defects is poor state for the transaction slab bridge entrance and should be noticed during construction phase well. The minor defect is settlement for the transaction slab and leak of backfilling within it.

Chart [8] Supports and cladding defects in the bridge sample

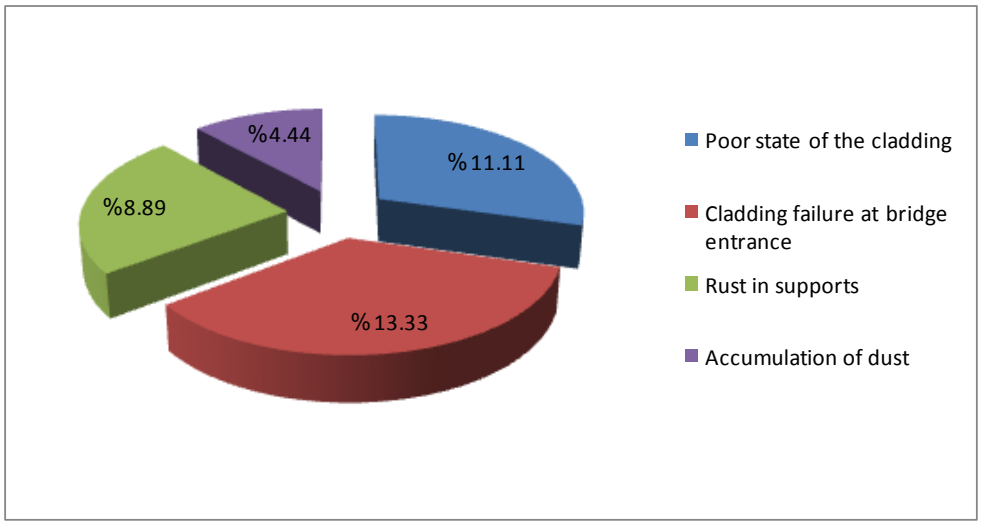
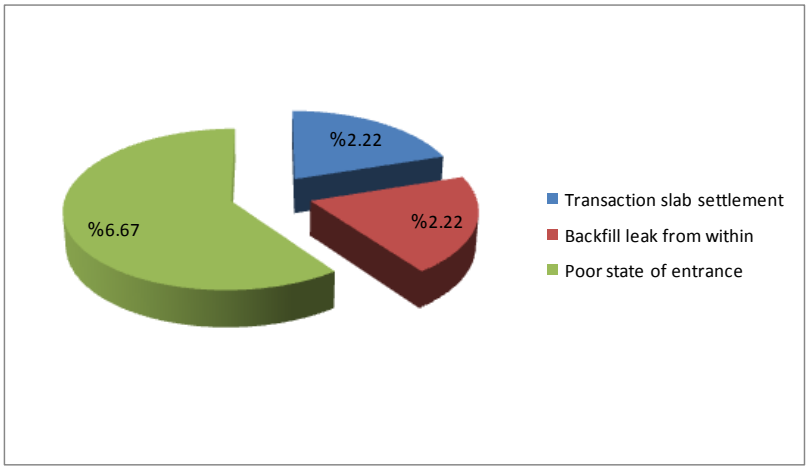


Table [8] Transaction slab defects in the bridges sample

S.N.	Defect Type	Frequency percentage (%)
1	Transaction slab settlement	2.22
2	Backfill leak from within	2.22
3	Poor state of entrance	6.67

Chart [9] Transaction slab defects in the bridge sample



4- MAINTENANCE STRATEGIES

Maintenance strategies include (nothing to maintain) that is concerned no maintenance at all till the repair become essential. Also the management of the bridge network should be performed at two different level, the routine maintenance level and the level at which a defect or the problem to be a medium to great importance of a structural or functional nature is detected.

5- CONCLUSION

It was noticed that bridge elements that have large and minor percentage of defects are slabs (22%) and cladding (5%). The main defects in slabs are Voids and cavities in slabs, Appearance steel bars in the slabs and No concrete cover.

It was noticed that main reasons that lead to the mentioned status are no available maintenance database, routine maintenance need to be more effective, trucks maximum axial load should be according to the accepted limits and also it should be used bridge management systems in order to provide data base with every bridge and its maintenance history.

6- RECOMMENDATION

It is recommended to overcome the bridge problems to maintain suitable Bridge Management System in Egypt taking into consideration the current status of the bridges and the maintenance. Also it is recommended to prepare and apply questionnaire to collect the required parameters that should be included to the Bridge Management System in Egypt.

REFERENCES

[1] Cheng, M. Y. and Hoang, N.D. "Risk score inference for bridge maintenance project using Evolutionary fuzzy least squares support vector machine", Journal Comp. civil Eng., 2012, 10.1061 / (ASCE) CP. 1943-5487. 0000275, 04014003.

[2] Das, P.C. "Priorization of bridge maintenance needs" Case studies in optimal design and maintenance planning of civil infrastructure systems, D.M. Frangopol, ed., ASCE, Reston, Virginia, 1999, PP. 26-44

[3] Yang, T., Hsieh, M.Y., and Kung, O.L., "Parallel computing platform for multi objective simulation optimization of bridge maintenance planning", J. Constr. Rng. Manage., (2012) 138 (2), PP. 215-226.
[4] Shan, D. and Li, Q. "Development of a smart-client based bridge management and maintenance system for existing highway bridges", International conference on Transportation Eng., 2009, PP. 3694-3699
[5] Lin, M. and Frangopol, D.M. "Balanacing connectivity of deterioration bridge networks and long-term maintenance cost through optimization "Journal Bridge Eng., 10 (4), 2005, PP.468-441
[6] Elag, Tahas and Wang, Y.M., "Risk assessment for bridge maintenance project: Neural networks versus regression techniques." J. Compu. Civ. Eng., 2007, 21 (6), 402-409
[7] General Authority for Roads & Bridges and Transportation in Egypt
[8] www.surveysystem.com/sample-size-formula & www.surveymonkey.com/mp/sample-size-calculator