THE STUDY OF SAFETY SURVEY EXPERT SYSTEM FOR REINFORCED CONCRETE STRUCTURE

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Abstract: Under the island-type climate in Taiwan, reinforced concrete (RC) structures grow old with time and develop symptoms of cracking and peeling off. Therefore the survey and evaluation of the durability of such structures has become an indispensable concern. Factors that influence the durability of reinforced concrete include the materials used, there relative proportion of construction procedure employed, the exertion of outside forces, environment conditions and many other things. Safety survey of concrete structure should be carried out throughly and frequently so that prevention measures can be taken in advance, the service life can be prolonged, and the cost for repair after serious damage can be avoided. Through an integrated protective covering of steel, concrete resistivity and corrosion potential. carbornate analysis of the above parameters, the health condition of concrete can be diagnosed and the safety of reinforced concrete structure can be estimated. This would provide reference for repair cost planning so that decision can be made concerning optimal repair method, the timing of repair and the saving of repair cost. Through the avoiding of accident or the arousing of alertness in advance, the objectives of both the objectives of both economical and safety considerations can be achieved

Keywords: Concrete, Durability, Corrosion, Carbonattion, Safety survey, Expert System.

1 INTRODUCTION

In construction techniques, the reinforced concrete (RC) structure is the most popular method. However, under the severe wind and salted weather, RC structures easily grow old with time and develop symptoms of cracking and peeling off. It is not easy to find out the cracking and peeling off, until the corrosion happens. Once the symptom appears outwardly, the damaged structure will causes the cost of maintenance fee and reduces the durability of the structure. Because RC structures easily grow old with time and develop symptoms of cracking and peeling off, the evaluation for repairing in order to extend the durablility of the building, is necessary. The method has provided the proper proposal, based on the econoimcal and safely consideration. The expert diagnostic system, being use well-developed and easy-to-use automatic machinery, became feasible to the work. Thus, the technique reduces the difficulty of test and making possible for the evaluation for the safetly of RC structure. [1] or [2].

2. STRUCTURE TEST OF RC

The solution for preventing the corrosion of RC is still under investigation, because the RC is non-uniform material and is hard to examine the exact symptom for causing the corrosion. Although some non-destructive insturment has been developed, most of methods for test the corrosion still relies on the visual testing. So far, the maintenance technique for the RC is still weak, and the long-term amendment for the old RC for the continuous corrosion became a dangerous hidden crisis. Therefore, The RC examination, through a throughly checking of safely items, and diagonosis of serious corrotion for the structure, can provide the warning for the building, in order to extend the age and preventing the huge cost for the damaged structure.

The corrosion of mid-steel in RC is similar to the corrosion of metals. However the steel encolsed by akali and concrete-mixed cause the difficulty of diagonosis of the first stage. Once the abruption on the RC suface happens, the basic strucure has been

seriously corosion and effect the structure of the building. Preventing the errosion is superior to the maintence after the damage. If the structure can been tested, the result can provide the information for the classification of responsibility, the improvement of the future design and refer for construction. It is necessary to have the proper test techniques.

concrete resistivity, an integrated protective covering of steel, concrete resistivity and corrosion potential. carbornate analysis of the above parameters, the health condition of concrete can be diagnosed

2.1 Safety test flow chart

Understanding factors for the durability of RC, the treatment can be arranged according to the test items, as the figure 1.

2.2 Safety test examination process

Through the analysis of influence factors, the health condition of concrete can be diagnosed and the safety of reinforced concrete structure can be estimated.

2.2.1 Visual appearance test

After viewing the abruption, cracking, and leakage of corrosive water, and peeling off, it is necessary to mark out the abnormal location as in Fig.2. The marked location became the prior part for examination. Those data can be established as a basic compared group. By considering time and budge, we can make decision for other tests. Also, by comparing the group, the healthy condition of structure can be graded.

2.2.2. The protective covering of steel

The durability of RC protective covering of steel is main factor to resist the corrosion. The proper protetive covering can make the structure durable.

2.2.3. Carbonation depth

In RC, the strong akali can protect the steel structure from corrosion. The sample of protected depth of cabonation can be taking by drilling the RC cylindrical sample. The PH value can be done by spread the penolpthalein on the surface. If PH value is great than 9.5, the test place will be showing purple, signifying the strong akali state of RC. If the color is not change, that is in neutral state.

2.2.4. Chloride concentration

Beside the carbonation, the high chloride ion concentration can decrease the PH value and damage the RC protected surface. It will cause the steel is easily corrosive.

2.2.5 Permeability test

The more permeability is, the more corrosive of RC is. The Resistively Logger is simple electronic equipment for permeability test. By the conductivity of Wenner Array law, the permeability test can be taken. The values for resistively logger indicate the resistance of the corruption of steel.

Table 1 RC resistivity vs. the corruption of steel

RL resistivity of RC (unit: Kohm.cm)	Corrosion of RC and Corruption of steel
<5	Highly possible
5-10	Possible
10-20	May be happened
>20	Seldom

2.2.6 Corrosiont test of RC

The application of Hall Cell Surveyor, by using copper and $CuSO_4$ poles, can easily and fastly test the Electrical Potential of RC mid-steel corruption. By analysis of RC corrosion, the distribution of errosion can be displayed. Fig.3 is an electric potential to display different colors for each individual degree of corrosion. Before the maintenance, the analysis of inclusive tests, evaluation of degree of corruption, and marking out the serious damage parts and classified, the results can provide trail for the priority of reinforcement, in order to secure the structure and to reduce the cost and time.

3. The strcuture of RC safety test expert system

In order to make whole safety test systematically, he study propose the infrastructure of the RC safety test as in the Fig. 4. The figure contains the collected data for individual case, the schedule for the test plan, the procedure for collected data, the numerical analysis, and the printing out data sheet. The result also proposes optimal repair method, the timing of repair and the saving of repair cost. The method also provides the individual step along with individual working sheet. In the standard structure, each sheets has sorted by computer software in order to be automation.

First of all, according the flow chart, the data for the building are built up, which includes the basic information for the future reference. The data also includes the each test unit according the order of floor, the individual district, blocked area, and labeled parts. Each label will be the identification from the beginning to the end. Each processed unit,

according to its size, has been arranged the proper size and numbers for the test. For example, a 4mx3m wall is located in the a room of the second story of the build. You can subdivide the wall with 48 blocks of 0.5mx0.5m area, then each block can be as a sampling point. The data input sheet can arrange a 8x6 data sheet in order to collect the following tests record.

Now, the structure is under test. The system provides 8 test items, and each individual test result will be represented by alphabet from A to H. The evaluation result classifies with 3 classes. The "1" signifies good condition. The "2" signifies pass. The "3" signifies fail. Once the result is "3", the immediate repairing action must be taken. In first item of test is visual test, the results classfy with three grades:A1,A2,and A3. According to the visual test, the evaluation decide whether the next step is necessary. For example, if the building is evaluated to A3, the immediate repairing action must be taken, rather than going through other test processes. In other case, if the grades are A1 or A2, the other procedures must be taken before the decision making. The tests includes: the protective covering of steel, carbonation depth, chloride content, concrete resistivity, corrosion potential, integrated protective covering of steel, concrete resistivity and corrosion potential. and carbornate analysis. Through, analysis of the above parameters, the health condition of concrete can be diagnosed and the safety of reinforced concrete structure can be estimated in Fig.5, 6. This would provide reference for repair cost planning so that decision can be made concerning optimal repair method.

Among the test items of the expert survey system, beside the first item as the qualitative analysis, the others are quantative analysis. All of those provide quantative data for each individual item to represent the physical factors of test samples. It is easy for a computer software to analyse those result to provide the objective aid for repairing and maintenance. Thus, the system can reduce the human abitration error and reach the goal of the standard operation, systematic procedure and automation.

Beside all those test items, the treatment to reach the correct treatment have relied the standard test procedure and fair principle for evaluation, thus, the scheduled test items is according to the R.O.C Standard and ASTM. If the items is not included in those principles, the empirical result will be considered.

The expert system is a development enviroment. Beside the general rule of evaluation, the software can be modified, according to those expertize of each individual expert, in order to make the system update and new. Through this open system, the experience of the survey can be collected and be graduately mature. By collecting each case, the data base can be established. Through, the acquiring and comparing the data base, the case can feedfack to the procedure, and reducing the repeatibiltity of the work. By the way, it can saving the cost and resource, reducing the procedure for safety examination, and promote the economic interest, for all popular applied purpose.

4. The application for RC safety test expert system

According the standard operation procedure, all the design sheet apply to each individual case, in order to evaluate the possibility and fitness of the system.

In this case, a case including wall, board, pillar, and poll, as individual elements, is tested. The system simplify the mode of analysis, and make pillar and poll as a surface, similar wall and board, as 8x6 =48 individual block to be analysed. The result is shown in Fig. 7. [1] or [2].

5. CONCLUSION AND SUGGESTION

According to the preliminery evaluation result, the following conclusion and suggestion are made:

5.1. Conclusion

1. The system, different from the previous expert system by viewing, is automation, integration of trivial scientific instruments, and statistics of the test results. It can provide the most precise treatment.
2. The system has defined the decision percentage, according to the pratical case. It has been proved to be reasonable.
3. The system simplify the mode of analysis, and make pillar and poll as a surface, similar wall and board, as 8x6 =48 individual block to be analysed. In general, the distribution can be represented for the case. But, the elements is less than 8x6 or irregular size, the resizing of the sheet must be modified in order to fit the case.
4. Some classified items, including the drill strength, the concentration of cluride, and carbonation, are sampled, and it may not be fair. The ensemble must be taken by proper collection of each sample.
5. Automatic test equipment to make the survey of RC structure more efficient, is more simple. Through the analysis of healthy of RC, the safety of RC, .Under the safety consideration, it can save the cost and resource, reduce the procedure for safety examination, and promote the

economic interest, for all popular applied purpose.

5.2. Suggestion

1. The system is still under invention between instrumentation and software development, and it cannot establish the automatic data collection in order to reach the automation.

2. The instrumentation for the future development can promote the efficiency for the future.

3. The interactive interface for friendly use of this software is still need to be improved

4. The system has been proved to be used in the analysis for the simple structure. Other complicate cases will conduct through aid of the expertise.

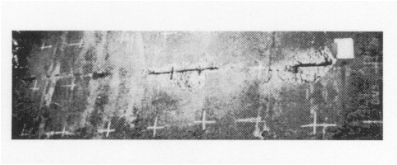

Figure 1. International Association .....

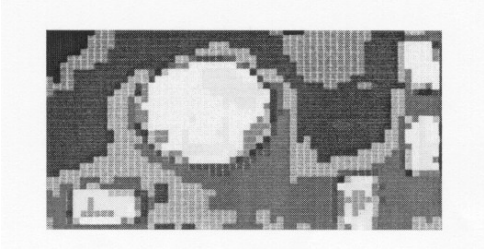

Figure 2. International Association .

Acknowledgments

This is how to do an unnumbered subsection. which comes out in 12 point font. Here I thank my colleagues.

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