THE DEVELOPMENT OF A PORTABLE SIDEWALKS MAINTENANCE MANAGEMENT SYSTEM

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ABSTRACT

Sidewalk is one of the facilities, which is relative with each citizen's livelihood. The facility of the sidewalks is not only provides walk for people but also is a key factor of a city's development and improvement. If made roads as blood vessels due to roads can let traffic transporting in all directions, then sidewalks can be made as the blood capillaries in each city. The main functions of sidewalks not only provide people walking but also supply a utility of prettifying environment, entertaining, and so on. So an appropriate sidewalk system is a sign of modernization and advancement for each city.

This research investigates several using influences factors, which were collected from papers and reality investigations. This research uses scientific tools including Delphi Method, Analytic Hierarchy Process, and Fuzzy Theory to analyze and establish a preliminary evaluation model of sidewalk maintenance management. In order to use this model pragmatically, this research also establishes a portable system. With this portable system, inspectors can use PDA to investigate problems of sidewalks outside and can collect these problems to input to the system. Then this system can calculate all the investigation data of sidewalks to sort what section of sidewalk should be repaired first. So, through this prototype sidewalks maintenance management system, sidewalks can be made with an optimization solution.

KEY WORDS

sidewalk system, delphi, AHP, portable maintenance management system, optimization solution.

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PREFACE

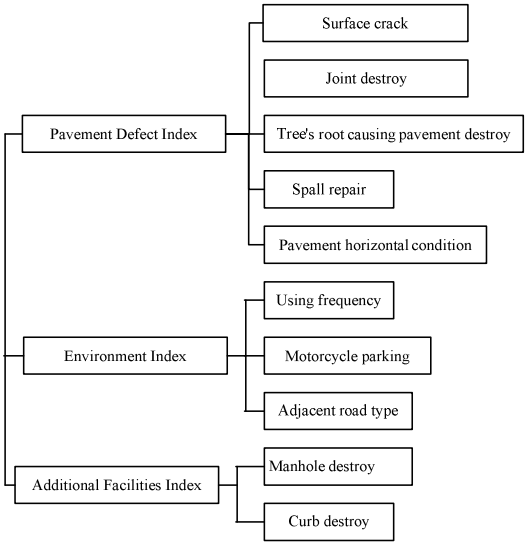
Walking is the basic method to move for humans. Although, there are lots of vehicles today, short distance transportation still needs to work by walking. So it's an important function for people to walk in a convenience sidewalk system. The development of each urban composes with essential factor, which is people, and walking is the necessary method for people to move around the urban region. Thus, an appropriate sidewalk system in a modern city must provide a safety, comfortable, and quick facilities for citizens to use.

It's an important issue for keeping sidewalk system in well condition to guarantee its performance. To develop a sidewalk evaluation algorithm, this research uses analysis tools of Delphi , analytic hierarchy process (AHP), and fuzzy theory by questionnaires to build up the model of assessing sidewalk conditions, and to establish the repair's priority. This research also uses computing technology to build up an analysis system which can collect record existing data of sidewalk at outside and analyze optimum maintenance decision at inside.

ASSESSMENT MODEL BUILD UP

In general, there are two kinds of sidewalk, including concrete pavement and brick pavement. This research uses the following steps to build up the evaluation system:

1. Establishing the assessment hierarchy: First, this research uses technical literatures and interviews several experts to build up the original guestionaire and influence hierarchy. Then, uses Delphi method to make revised questionnaire. figure 1 and figure 2 are the final result.



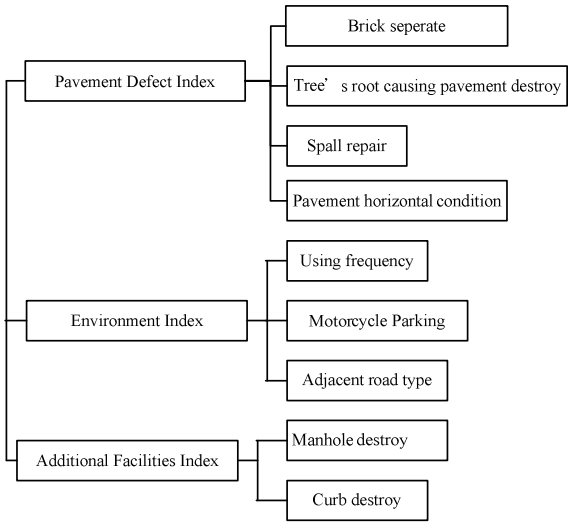


Figure 1: The evaluation The Hierarchy of Concrete Pavement Sidewalk

Figure 2: The evaluation The Hierarchy of Brick Pavement Sidewalk

2. Confirming the weighting of key performance index (KPI): Because this hierarchy involves lots of index factors, so need to compare their relations to determine each weighting factor. This research uses AHP method and questionnaire to drive the weighting factors. Table 1 and table 2 are the driving result by using AHP calculation.

Table 1: Weighting Factors of Concrete Pavement Sidewalk

1st layer	Weighting Factors (W1)	2nd layer	Weighting Factors (W2)	Final weighting(W1xW2)
Pavement Defect Index	0.31	Spall repair	0.17	0.05
		Tree's root causing pavement destroy	0.21	0.07
		Pavement horizontal condition	0.20	0.06
		Joint destroy	0.18	0.06
		Surface crack	0.24	0.07
Environment Index	0.34	Using frequency	0.35	0.12
		Motorcycle parking	0.34	0.12
		Adjancent road type	0.31	0.11
Additional Facilities Index	0.35	Manhole destroy	0.53	0.19
		Curb destroy	0.47	0.16

Table 2: Weighting Factors of Brick Pavement Sidewalk

1st layer	Weighting Factors (W1)	2nd layer	Weighting Factors (W2)	Final weighting(W1xW2)
Pavement Defect Index	0.31	Brick separate	0.31	0.10
		Tree's root causing pavement destroy	0.18	0.06
		Spall repair	0.24	0.07

		Pavement horizontal condition	0.27	0.08
Environment Index	0.34	Using frequency	0.35	0.12
		Motorcycle parking	0.34	0.12
		Adjancent road type	0.31	0.11
	0.35	Manhole destroy	0.53	0.19
		Curb destroy	0.47	0.16

3. Establishing the level of KPI: Because each assessment factor has its different cognition, so it must be identified with every situation in each factor. This research uses fuzzy theory to statistics the cognition of citizens from these assessment factors. The membership value calculated from questionnaire to derive three grades of its membership function within each assessment factor. The calculation results of joint destroy factor are shown in figure 3 to figure 6.

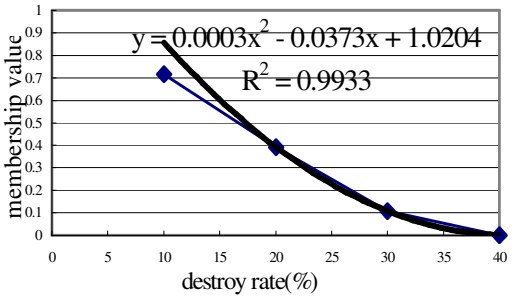


Figure 3: Grade A of Joint Destroy

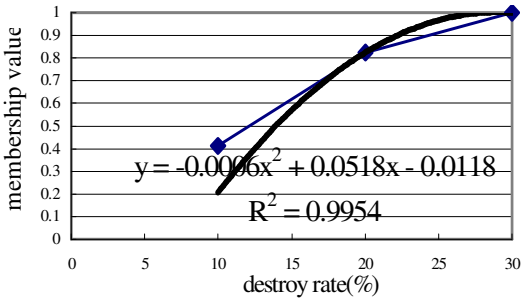


Figure 4: Grade BL of Joint Destroy

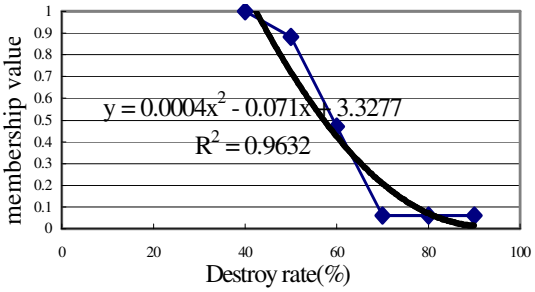


Figure 5: Grade BR of Joint destroy

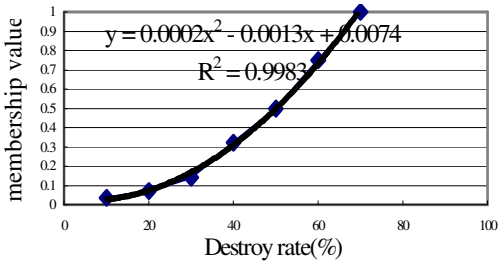


Figure 6: Grade C of Joint destroy

4. Verifying assessment model: In order to simulate the reliability of this model, this research collected 33 people's opinions after practice to survey rank 5 selected sidewalks, and then

derives the comparing situation of these sidewalks. Such comparing result is the same as programming result (table 3).

Table 3: Statistic and Comparing

Section	Statistics of sidewalk condition					Comparing result by people's survey	Comparing result by assessment model
	1st	2nd	3rd	4th	5th		
Section A	5	4	12	10	2	3	3
Section B	3	8	10	6	6	4	4
Section C	13	10	6	4	0	1	1
Section D	12	9	6	5	1	2	2
Section E	0	4	4	5	20	5	5

MAINTENANCE SYSTEM INTRODUCTION

There are two major parts of this sidewalk maintenance management system. The first part uses personal digital assistant (PDA) to collect sidewalk conditions fields. The second part uses PC to translate data from PDA and to analyze for deriving the condition result which can be compared for the maintenance priority.

1. On-site use of Portable system Development: This research selects WinCE system as OS of PDA hardware and Embedded Visual Basic as software. The development process is shown as figure 7.

Once this PDA system is executed, the copyright description will automatically show on the screen. User can choose the "About" button to read introduction screen. The "Enter" button will allow user to get into ID check frame. Once the user inputs correct username and password, system can show the sidewalk basic data frame (figure 8). User can use "Next", "Previous", "First", and "Last" buttons to explore data and information. If any user wants to explore in detail data, user can select "Show Detail" button to look (figure 9).

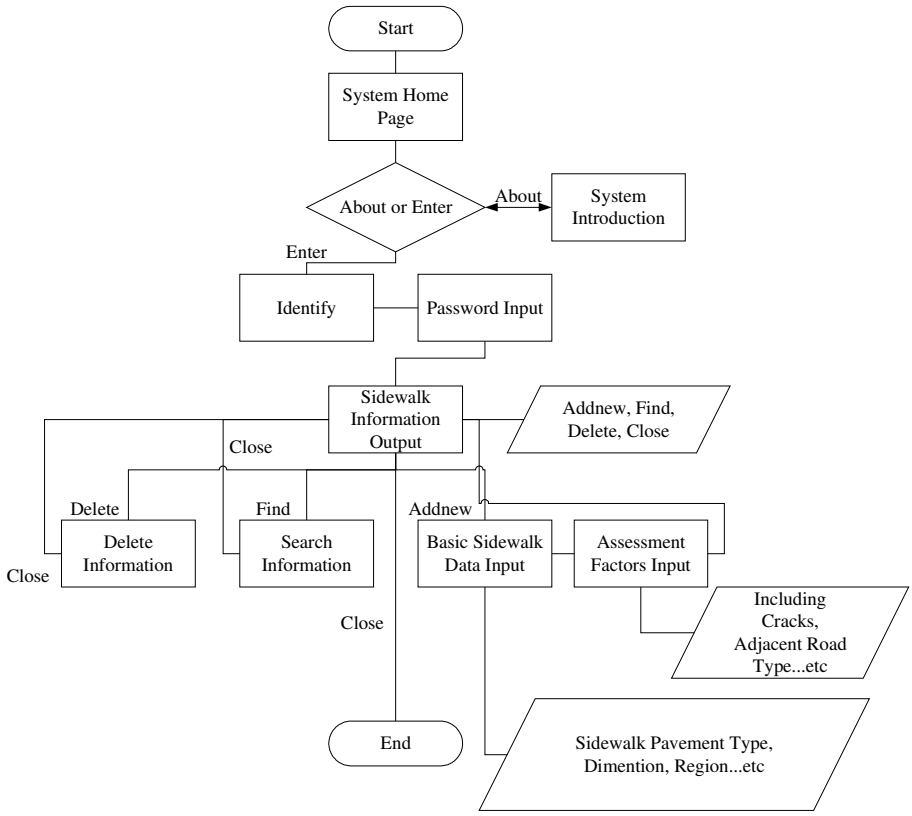
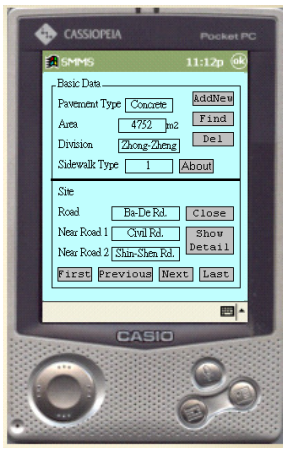


Figure 7: The Folw Chart of PDA system



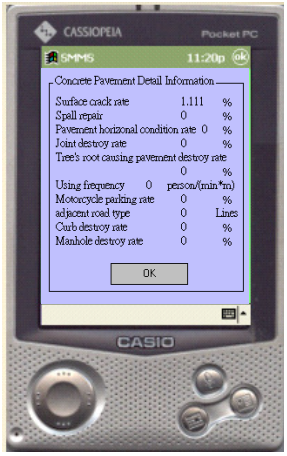


Figure 8: General Information of Sidewalk Figure 9: Detail Data of sidewalk

Because there are two major types of sidewalk pavement concrete and brick, so before user inputs inspecting data, he/she must decide what type the pavement is. Then user can

click “input” button to input existing data of the inspecting sidewalk. If the user wants to refer specific sidewalk, he/she can click “Find” button to enter road name to get the right information (figure 10). If user wants to delete specific sidewalk information, he/she can click “del” button to do it. On the other hand, if user wants to create a new sidewalk inspection data to this system, he/she can just click “addnew” button to do it. Then the system will allow user to input general information (figure 11). Because there are lots of inspection items to input, the PDA screen does not show all items at the whole screen. So this system provides a scroll bar to let user conveniently input by switch screen (figure 11). The program code of “addnew” function is shown in figure 12.

Figure 10: The Input Screen for Finding Specific Sidewalk

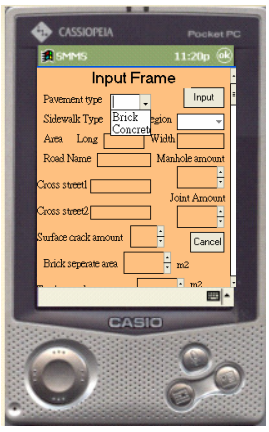


Figure 11: Adding New Data Screen

```
Private Sub Command2_Click()
  Dim rs2 As ADOCE.Recordset
  If connOpen = True Then
    Set rs2 = CreateObject("ADOCE.Recordset.3.0")
    On Error Resume Next
    rs2.Open "select * from data", conn, adOpenDynamic, adLockOptimistic
    If combo_add1.Text = "concrete" Then
      If combo_add1.Text = "" Or Combo2.Text = "" Or Combo3.Text = "" Or Text17.Text = "" Or _
      Text18.Text = "" Or Text3.Text = "" Or Text4.Text = "" Or Text2.Text = "" Or Text5.Text = "" Or _
      Text7.Text = "" Or Text9.Text = "" Or Text8.Text = "" Or Text10.Text = "" Or Text11.Text = "" Or _
      Text13.Text = "" Or Text14.Text = "" Or Text15.Text = "" Or Combo4.Text = "" Or Text12.Text = "" Or Text16.Text = "" Then
        MsgBox "error! Some items not input!", vbOKOnly + vbInformation, "message box"
      Else
        rs2.AddNew
        rs2("pavement type").Value = combo_add1.Text
        rs2("sidewalk type").Value = Combo2.Text
        rs2("partition").Value = Combo3.Text
        rs2("long").Value = Text17.Text
        rs2("with").Value = Text18.Text
        rs2("交點1").Value = Text3.Text
        rs2("交點2").Value = Text4.Text
        rs2("road name").Value = Text2.Text
```

Select sidewalk pavement type.

Input inspection data and calculate the rate of the sidewalk.

Figure 12: Program Code of “Addnew” Function

2. The analysis and display system of PC: This research uses PC to gather data from PDA to analyze sidewalk's grade. The analysis result can provide sidewalk managers to make maintenance decision. The critical information is about "To display the grade and the membership value of KPI in each sidewalk", "To display the rank of KPI in each sidewalk", and "To display condition rank of all sidewalks". This research uses Microsoft Visual Basic to design this system on PC and uses Active Database Object (ADO) to assess database. This system can transform database format from PDA to PC. The PC system can read database which transformed from PDA to input membership function to produce analysis information.

figure 13 is the homepage screen of this PC system. User can click "About" button to show system introduction (figure 14). If user clicks "Into main system" button, the screen will show a database management menu which involves: (1) "Database transform"-it can transform database format from PDA to PC, (2) "Read database"- it can read transformed database to PC, and use program function to calculate membership value, and (3) "Show analysis information"- it can show analysis result. Such program code is shown in figure 15.

After read database to analyze program, user can look analysis result in "Analysis Information" frame. The analysis information menu contains 3 parts (figure 16). If user wants to know each KPI value of any inspected sidewalk, he/she can click "Road Name" button to input the road name (figure 17). Meanwhile, if any user wants to check each KPI value for all sidewalks, he/she can click "KPI Value for all sidewalks" button to select specific KPI grade. If user wants to check all sidewalks' condition, he/she can just click "sidewalks condition" button.

Figure 13: Main System of PC Screen

Figure 14: System Introduction

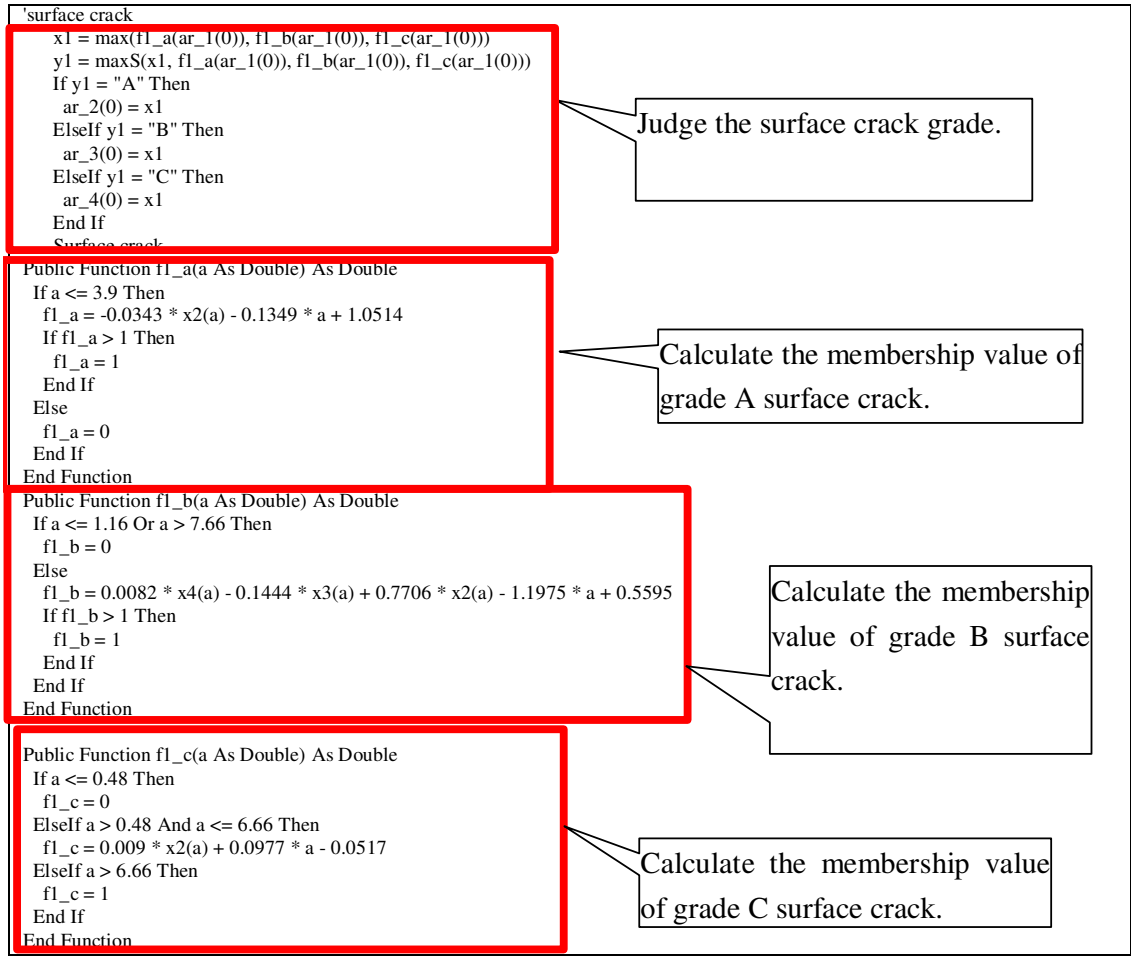


Figure 15: Program of Calculate Membership Values of Each Grade.

CONCLUSIONS

This research creates two separate modules, the first module is developed in a portable PDA system to allow inspectors check and input sidewalk's practice conditions right at the field, the second module is created to transform database of PDA to PC system, and derive the performance situation of inspected sidewalk. In addition, this system can be developed as a sidewalk maintenance management system (SMMS) to help engineers make appropriate maintenance strategy.

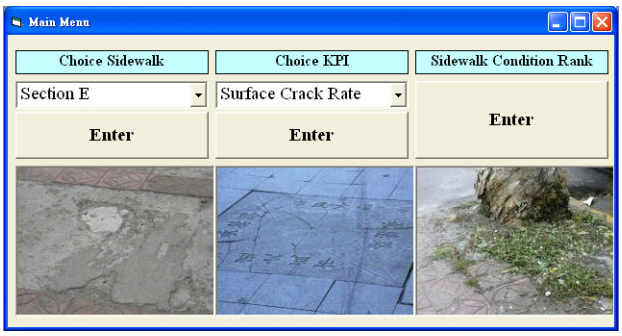


Figure 16: Analysis Information Menu

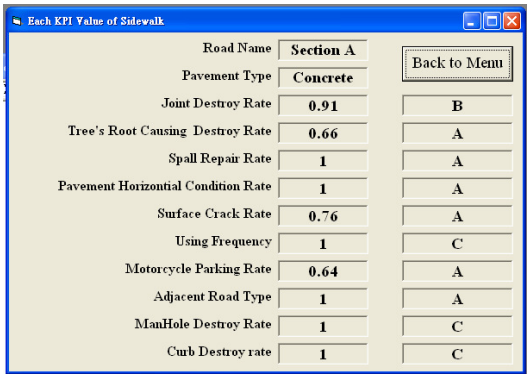


Figure 17: Grades of KPI Membership Values for specific Sidewalk.

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