WIN-DPOLES

DECISION MAKING SOFTWARE DEVELOPMENT TO DAMAGED POLES

USER'S MANUAL

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1.0 INTRODUCTION

The objective of this study is to develop a software program that can be used to evaluate the structural integrity of the damaged signal/light poles and sign structures. The benefits of such a program relates directly to the safety of the motoring public. An immediate decision can be made as to the integrity of the structure and the possible need to close the affected traffic lanes until the structure is removed.

There are seven types of poles accepted by the program:

1. Mast Arm Pole

2. Strain Pole

3. Light Pole

4. Square Light Pole

5. Pedestal Pole

6. Cantilever Sign Pole

7. Overhead Light Pole

Evaluation process is described in Section 2.0 – Assumptions and Evaluation. The input descriptions are listed in Section 3.0 – WIN-DPOLES. Results are shown in Section 3.8 where Combined Stress Ratios(CSR) due to load combinations of (1) Dead Load only, (2) (Dead Load + Wind Load)/1.33, (3) (Dead Load + 0.5 Wind Load + Ice Load)/1.33, are calculated by the program and shown on the screen. Decision based on the evaluation is shown in the comment block for user's reference.

2.0   ASSUMPTIONS AND EVALUATION

The program was written using Visual Basic 6.0[@], which gives an easy-to-use interaction with the user. The first screen includes general information like the date, time, inspector name, the street name and place, pole type, and pole number. From the top bar, the user can choose the type of pole he or she wants to evaluate. Each pole type has its own screen, which includes two tab screens. The first one includes questions to decide whether the pole needs to be evaluated numerically by the program, or if it has damage that requires replacement of the entire pole or the truss, in the case of sign poles, without calculations. The second screen, which shows up only if the pole has been bent and needs to be evaluated by the program, requests the necessary information to perform the evaluation. Two types of information are required, damage information and pole properties, including the properties necessary to calculate the loads.

Many assumptions were made to simplify use of the program and require only the necessary information to be input by the user. These assumptions were made based on information provided by the Maryland State Highway Administration (SHA) or use of the standard drawings for the poles. The weight of the signals is assumed to be 20 lb/head including attachments, and the sign weight on signal poles is assumed to be 5 psf. Weight of the cable for strain poles is assumed to be 0.6 lb/ft including attachment. Weight of mast arm is calculated based on the length of the mast arm which helps to define the diameter and thickness of the arm. For sign structures, weight of the signs is assumed to be 9 psf. Variable Massage Sign (VMS) are assumed to be 100 lb and (3ft*3ft) dimensions for cantilever sign structures. For overhead sign structures, VMS is assumed as 6500 lb weight and (32ft* 8ft) dimensions. Luminaires are assumed to be 70 lb and have a 3sq-ft projected area. Detector is assumed to be 100 lb in weight and 5 sq-ft.

The program starts the evaluation by calculating loads at the location of damage, taking all possible loads into consideration such as axial load, shear force, flexural moments in both directions, and torsional moment. Properties of the damaged section are calculated including damaged sectional area and the moment of inertia with respect to both x and y axis in addition to the axis perpendicular to the damage angle. Moment of inertia for the damaged section is calculated using damage width and depth. Stress concentration is calculated using damage height and depth. Imperial formulas were generated from enclosed graphs, which were obtained from reliable references. Evaluation of the damaged section is performed at six locations: (1) at zero angle; (2) at 180 degree angle; (3) at 90 degree angle; (4) at 270 degree angle; (5) at angle equal to angle of damage; (6) at angle equal to the angle of damage + 180 degrees counterclockwise. For square light pole, the damaged section is evaluated at eight locations all around the pole at increments of 45 degrees. The maximum combined stress of these six or eight cases is considered for each load combination.

The result screen, which is the decision making screen, includes the combined stress ratio (CSR) for the three load combinations as required by AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals". Also, it includes the angle corresponding to the CSR. If the CSR is found to be greater than one for any of the three combinations, that cell will turn to a red color informing the user that the CSR exceeds the

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allowable limit. For the signal poles, another case called Maximum Condition is checked which calculate the CSR for the damaged pole under the standard loads. This procedure is done to account for the probability of adding new signals to the pole in the future. The screen includes the general information that the user input in the first screen is to be printed as a part of the final report. The judgment will be in the comments area which will be one of the following cases:

1. "Pole is safe, based on the input data" if CSR <1.0 for the three load combinations.

2. "Replace Pole immediately" if CSR >1.0 for the three load combinations.

3. "Replace Pole " if CSR >1.0 for the second or third load combinations or both of them but CSR < 1.0 for the dead load.

4. "Replace Pole due to …" if no numerical calculations are performed and the pole is to be replaced due to one or more of the listed reasons.

5. One of the first three cases in addition to comment "Replace truss due to …" for the sign structures only when the pole has a dent and the truss needs to be replaced for one or more of the listed reasons.

3.0   WIN-DPOLES - DECISION MAKING SOFTWARE DEVELOPMENT TO
       DAMAGED POLES

3.1   How to Run DPOLES

       1.   Fill the information on the Header page (Figure 3.1).

       2.   Select type of pole from the option button on the menu bar.

       3.   Fill the detailed information on the two tab pages (Figures 3.2-3.8).

       4.   You may print the information page by hitting the Print key.

       5.   Hit Analysis key to get the result screen.

       6.   The decision making by the DPOLES program is shown on the result screen (Figure
            3.9). You may print the screen by hitting the Print key or Exit the program.

Figure 3.1 – DPOLES Header Page

3.2   Mast Arm Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of the Damage: Angle in degrees from the reference point (one of the arms) to the center of the damage (clockwise).

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top (Dt):   Outside diameter of the pole at the top which will be calculated by the program depending on the slope of 0.14 inch per foot of the total height. This will appear when the user puts the cursor in the designated cell and it can be changed by the user if it does not match the actual case, in inches.

Thickness: Thickness of the pole in inches and it is calculated by the program, depending on the data base available with standard dimensions. Thickness will appear when the user puts the cursor in the cell (Dt), Previous cell, in inches

Number of Arms: Total number of arms supported by the pole under consideration.

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications).   The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

TABLE:

Arm Length: Distance from the pole center to the tip of the particular arm, in feet.

Angle Beta: Angle measured clockwise from the reference point (arm number 1) to the designated arm. (For arm number 1, beta is zero as the default.)

HA (Height from the base):   Height of the arm - distance from the base plate to the center of the arm flange plate.

Signal:

# of Heads: Number of heads for signal number 1, 2, ..., 8.

Dist.:   Distance from the pole center to the center of signal 1, 2, ..., 8, in feet.

Sign

Area: Area of sign number 1, 2, 3, in square feet.

Dist.:   Distance from the pole center of the center of sign number 1, 2, 3, in feet.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

Figure 3.2 – Master Arm Input Page

3.3   Strain Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of Damage: Angle in degrees from the reference point (one of the cables) to the center of the damage (clockwise).

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top (Dt):   Outside diameter of the pole at the top which will be calculated by the program depending on the slope of 0.14 inch per foot of the total height. This will appear when the user puts the cursor in the designated cell and it can be changed by the user if it does not match the actual case, in inches.

Thickness: Thickness of the pole in inches and it is calculated by the program, depending on the database available with standard dimensions. Thickness will appear when the user puts the cursor in the cell (Dt), Previous cell, in inches.

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications). The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

Pole tilt: Inclination of the pole in inches per linear foot.

TABLE:

Span Length: The total horizontal distance from the pole under consideration to the other pole, which supports the cable, in feet.

Angle Beta: Angle measured clockwise from the reference point (cable number 1) to the designated cable. (For cable number 1, beta is zero as the default.)

HA (Height from the base): Vertical distance from the base plate to the point where the cable is connected to the pole, in feet.

Minimum Clearance: Vertical distance from the road (which is expected to be at the same level as the base plate of the pole) to the lowest point of the signal, which is expected to be 4 ft lower than the lowest point of the cable.

Sag. Horizont. Dist.: Distance from the center of the pole to the point of minimum clearance.

Signals:

Heads: Number of heads for signal number 1, 2, ..., 8.

Distance: Distance from the pole center to the center of signal 1, 2, ..., 8, in feet.

Signs:

Area: Area of sign number 1, 2, 2, in square feet.

Dist: Distance from the pole center of the center of sign number 1, 2, 3, in feet.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

DPOLES - [Strain Pole]

Exit | ○ Header ○ Mast Arm ● Strain ○ Cantilever ○ Overhead ○ Light ○ Square Lighting ○ Pedstal | Help | Print

Strain Pole - Questions | Strain Pole - Information

Sag horiz. dist.

HT

HA

Minimum clearance

HD

Analysis

DAMAGE INFORMATION
Damage Location (HD) [____] (in)
Damage Height [____] (in)
Damage Width [____] (in)
Damage Depth [____] (in)
Angle of the Damage [____] (deg)
(from the reference clockwise)

POLE INFORMATION
Total Height (HT) [____] (Ft)
Diameter Bottom (Db) [____] (in)
Diameter Top (Dt) [____] (in)
Thickness [____] (in)
Wind Speed (Def.=90) [____] (MPH)
Pole Tilt [____] (in/Ft)

| Cable No | Span Length (Ft) | Angle Beta (degree) | HA Height from the base (Ft) | Minimum Clearance (Ft) | Sag horizont. Dist. | Signal | | | | | | | Sign | | |
						1 # of Heads	1 Loc. (Ft)	2 # of Heads	2 Loc. (Ft)	3 # of Heads	3 Loc. (Ft)	4 # of Heads	1 Area (Ft^2)	1 Loc. (Ft)	2 Area (Ft^2
1		0													
2															

# of Heads is number of Heads for the signal.   Dist. is measured from the center of the pole to the center of the signal or sign.

Figure 3.3 – Strain Pole Input Page

3.4   Light Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of Damage: Angle in degrees from the reference point (one of the arms) to the center of the damage (clockwise).

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications). The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top (Dt):   Outside diameter of the pole at the top which will be calculated by the program depending on the slope of 0.14 inch per foot of the total height. This will appear when the user puts the cursor in the designated cell and it can be changed by the user if it does not match the actual case, in inches.

Thickness: Thickness of the pole in inches and it is calculated by the program, depending on the database available with standard dimensions. Thickness will appear when the user puts the cursor in the cell (Dt), Previous cell, in inches.

Length of Arm (LA):   Horizontal distance from the center of the pole to the tip of the arm.

Height of Arm (HA):   Vertical distance from the base plate of the pole to the point where the arm is connected to the pole, in feet.

No. of Arms: Number of arms supported by the pole (1 or 2).

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.
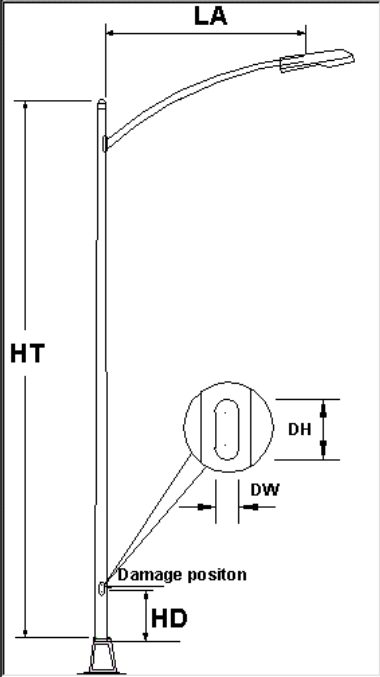

Figure 3.4 – Light Pole Input Page

3.5   Square Lighting Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Angle of Damage: Angle measured clockwise from the reference point (one of the luminaires) to the damage face. It has to be 0, 90, 180 or 270 degrees if the damage case is case 1, and 45, 135, 225, or 315 if the damage case is case 2.

Damage case: 1, if the damage is in one face, or 2, if the damage is in two faces.

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications). The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Side length Bot. (Dmb):   Side length close to the base plate, in inches.

Side length Top (Dmt):   Side length at the top of the pole. It is calculated by the program and can be changed by the user if it does not match. It will appear when the cursor is on the mentioned cell.

Thickness: Thickness of pole wall (default) and can be changed by the user, if it does not match the case.

No. of luminaires: The number of luminaires supported by the pole (1 or 2).

For case 1:

Damage width and depth are as shown in the figure of case 1. If damage case is chosen as 1, these cells have to be filled and the others for case 2 have to be blank.

For case 2:

Length of the damage in both faces A and B as shown in figure of case 2. If damage case is chosen as 2, these cells have to be filled while cells of case 1 have to be blank.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

Figure 3.5 Square Light Pole Input Page

3.6   Pedestal Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of the Damage: Angle in degrees from the reference point (the detector) to the center of the damage (clockwise).

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications). The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top (Dt):   Outside diameter of the pole at the top which will be calculated by the program depending on the slope of 0.14 inch per foot of the total height. This will appear when the user puts the cursor in the designated cell and it can be changed by the user if it does not match the actual case, in inches.

Thickness: Thickness of the pole in inches and it is calculated by the program, depending on the data base available with standard dimensions. Thickness will appear when the user puts the cursor in the cell (pmt), Previous cell, in inches.

Height of detector 1, 2(HDt):   Vertical distance from base plate to the center of detector 1, 2.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

Figure 3.6 Pedestal Pole Input Page

3.7   Cantilever Sign Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of Damage: Angle in degrees from the reference point (the arm) to the center of the damage (clockwise).

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications).   The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used. If the user means to use a different wind speed, the comment may be ignored.

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top: Outside diameter of the pole at the top, in inches.

Thickness: Thickness of the pole, in inches.

Height of Arm (HA):   Vertical distance from the base plate of the pole to the center of the Arm, as shown in the figure, in feet.

No. of arm long. members: Number of truss longitudinal members.

Diam. of arm members (DA):   Outside diameter of the previous members, in inches.

Thick. of arm members: Thickness of the previous members, in inches.

Area of sign: Area of sign number 1, 2, ... , in square feet.

Distance between centers of sign and pole: Horizontal distance from the center of pole to the center of the sign, in feet.

Do you have VMS sign: To use when there is a verbal message sign. If yes, the program will consider its weight as 100 lb and its area as 9 square feet; the user has to input its distance, in feet.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

Figure 3.7 – Cantilever Sign Pole Input Page

3.8   Overhead Sign Pole

Damage Location (HD):   Distance from the base plate to the center of the damaged area (as mentioned in the graph above) (in inches).

Damage Height: The height of the damaged area (the dent in the pole body) in the longitudinal direction of the pole, in inches.

Damage Width: Width of the damaged area (dent) in the transverse direction of the pole, in inches.

Damage Depth: Distance from the original shape of the pole to the deepest point in the damaged area, in inches.

Angle of the Damage: Angle in degrees from the reference point (the arm) to the center of the damage (clockwise).

Wind Speed: The wind speed is assumed to be 90 MPH as a default (as mentioned by AASHTO specifications).   The user can change the speed to match the specifications that he is analyzing; a reminder message, that the required specification is 90 MPH, will appear as the program is running if another speed is used.   If the user means to use a different wind speed, the comment may be ignored.

Total Height (HT):   Total height of the pole from the base plate to the tip, in feet.

Diameter Bottom (Db):   Outside diameter of the pole directly above the base plate level, in inches.

Diameter Top (Dt):   Outside diameter of the pole at the top, in inches.

Thickness: Thickness of the pole, in inches.

Span length: Overhead truss span length taken horizontally between support structures, in feet.

No. of arm long. members: Number of truss longitudinal members.

Diam. of arm members (DA):   Outside diameter of the previous members, in inches.

Thick. of arm members: Thickness of the previous members, in inches.

Area of sign: Area of sign number 1, 2, ... , in square feet.

Distance between centers of sign and pole: Horizontal distance from the center of pole to the center of the sign, in feet.

Do you have VMS: To use when there is a verbal message sign.   If yes, the program will consider a weight of 6500 lb. for the VMS, and dimensions of 32' × 8', the user has to input its distance, in feet.

Analysis: When choosing this option the program will continue the analysis and give results; it does not have to be chosen before completing the required data.

Figure 3.8 – Overhead Sign Pole

3.9   Results

Information on the banner page input by the user is shown on this result page. Combined Stress Ratios(CSR) due to load combinations of (1) Dead Load only, (2) (Dead Load + Wind Load)/1.33, (3) (Dead Load + 0.5 Wind Load + Ice Load)/1.33, are calculated by the program and shown on the screen. Current Condition is calculated based on the normal design load specified by the AASHTO and Maximum Condition is calculated based on the maximum design load assumed by the Maryland State Highway Administration. Decision based on the evaluation is shown in the comment block. Output of this page is saved under the name of the pole number.

Figure 3.9 – Result Page