9. The sign conventions used by the program are as follows:

   Loads: Positive when acting as shown in Figure 3.4.1.

   Reactions: V, H and M positive when acting as shown in Figure 3.4.1.

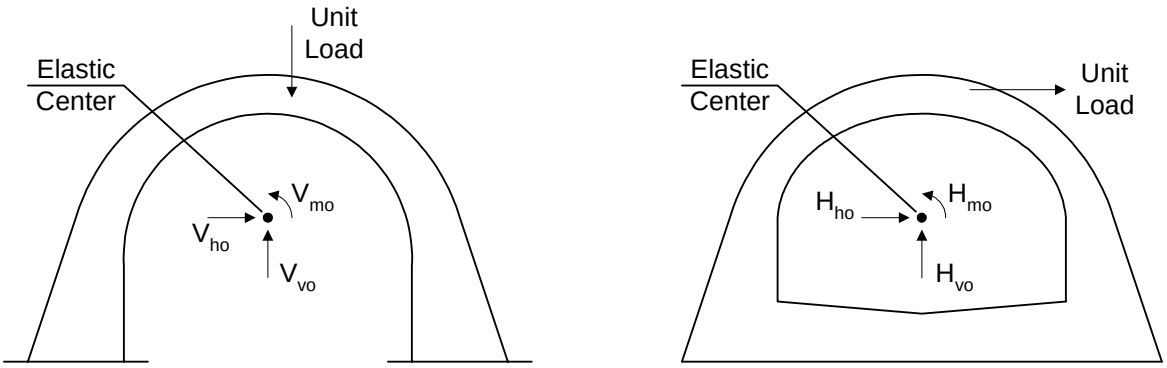
   Force Effects: Thrust and shear forces positive when acting as shown in Figure 3.4.1.

10. In the arch ribs and barrels, the amount of longitudinal reinforcement is equally divided between the intrados and extrados in accordance with AASHTO 8.14.3.4.

11. Effects of the full value and the reduced value of horizontal earth pressure are considered in accordance with AASHTO 3.20.2.

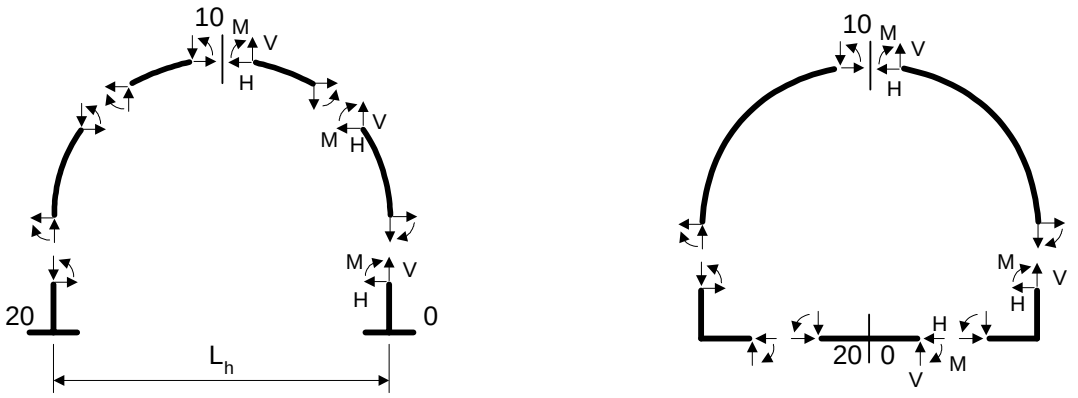
12. **The elastic center method of analysis used by ARCH does not consider axial deformation. Therefore, any attempt to match ARCH's analysis results using any multi-purpose structural analysis software must account for this assumption.**

Unit Loading



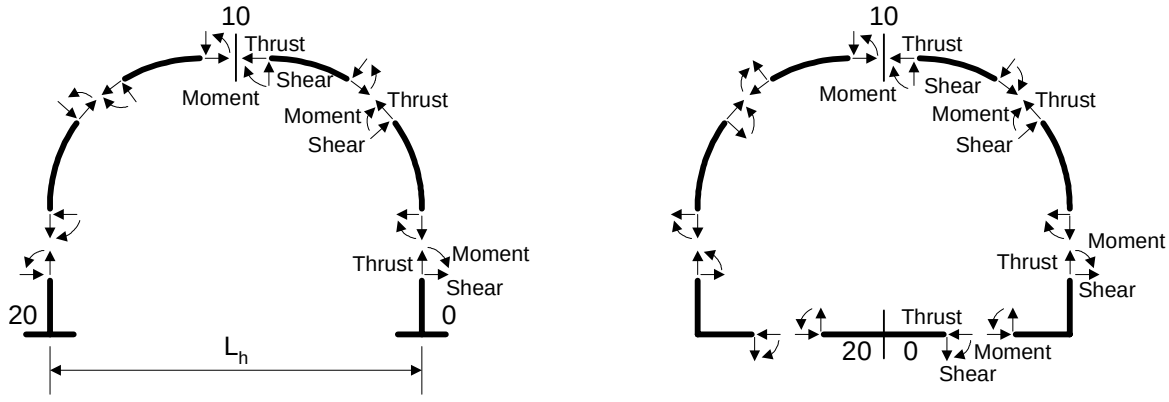
Fixed Arch **Tied Arch**

Reactions



Fixed Arch **Tied Arch**

Force Effects



Fixed Arch **Tied Arch**

Figure 3.4.1 - Unit Loading, Reactions and Force Effects

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A unit loading is applied just to the left of a cross section and then just to the right, causing an extra influence ordinate to be calculated. In other words, the tabulation of ordinates caused by unit loading at section 2 will show two sets of ordinates at point 2.

6.7 ANALYSIS RESULTS

The factored reaction, thrust, shear and moment effects at each segment cross-section are tabulated for the following loading combinations. For a design problem only, axial strengths and moment strengths are also printed. Moments are in kip-feet, reactions, thrusts and shears are in kips.

1. Vertical
2. Horizontal
3. Internal Effects - Rib Shortening, Shrinkage and Temperature Change
4. Group X
   - Vertical + ½ Horizontal
   - Vertical + Horizontal
5. Group X with Temperature Drop
   - Vertical + ½ Horizontal
   - Vertical + Horizontal
6. Group X with Temperature Rise
   - Vertical + ½ Horizontal
   - Vertical + Horizontal

NOTE: Results for Internal effects and Group X Loadings with temperature change are printed for fixed arches only. The sign convention for positive reactions (V, H and M) and for positive thrust and shear is defined in Figure 3.4.1. **A moment causing tension at the intrados or top of the tie is positive. A thrust causing tension in the ring or compression in the tie is positive. A shear acting downward to the right of the section is positive.**

6.8 DESIGN STEEL AREA AND SHEAR STRENGTHS (Design Only)

For each cross section of half of the arch, the following values are tabulated:

1. Thickness of the ring or tie, as supplied in the SECTION PROPERTIES Lines or as computed and as explained in the METHOD OF SOLUTION section.

2. Area of Extrados Steel.

3. Area of Intrados Steel.
4. Factored Shear.
5. Shear Strength.

For sections at which reinforcement is not required at either face, the minimum area of steel is printed. The minimum area of reinforcement is taken as one percent of the gross area of the section distributed equally between intrados and extrados steel as per AASHTO 8.14.3.4.

6.9 ERROR MESSAGES

The program prints an error message when an input error is detected. These messages are self-explanatory. The user should correct errors and resubmit the job for execution.

6.10 FORMATTED OUTPUT TABLES

The following pages contain the format (i.e., the title, output parameters, units, field widths and decimal locations) for each of the output tables described in this chapter. On each table, the character "a" represents a character value for that column, and the number of "a" characters shows the number of characters possible there. The character "i" represents an integer value for that column, and the character "x" represents a real value with the decimal location indicated. The characters "nn" represent the analysis point number at the connection point of the ring and the tie. For tied arches, output data is provided for the ring section and the tie section immediately adjacent to this point.

The output available for every run of the program may not include all of the output tables shown. Depending on such items as the arch type (fixed or tied), the influence line code, the geometry input method and reinforcement design, the program will print different combinations of these output tables.