Applying Gradient Boundary Conditions

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In order to create a gradient for the applied variable (such as a pressure, force, and velocity gradient applied to a boundary), one optional keyword phrase may be utilized with specific keywords. Here, the phrase is

“xvar”,vx,”yvar”,vy

The gradient's x- and y-variations for the force, stress, and/or velocity components are specified by the parameters **vx** and **vy**. The value varies linearly with distance from the global coordinate origin at (x = 0, y = 0):

$$V_{mod} = V_0 + vx \times x + vy \times y$$

where V_0 is the initial value at origin and V_{mod} is the modified value at (x, y). The operation of this feature is best explained by three examples:

Example 1: Apply Variable Velocity to a Vertical Boundary

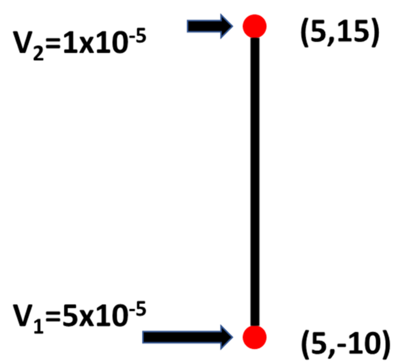

Figure 1- Apply variable velocity to a vertical boundary.

It is clear that only **vy** will be in effect for the vertical boundary and that the **vx** value is zero. The y-variation's equation is as follows:

$$V_{mod} = V_0 + vy \times y$$

The velocity at points (5,-10) and (5,15) are $5x10^{-5}$ and $1x10^{-5}$ respectively. The gradient equation will be written as follow:

$5x10^{-5} = V_0 + vy \times (-10)$

$1x10^{-5} = V_0 + vy \times (15)$

The values of **V0** and **vy** may be obtained by solving the set of equations above, which yields $3.4x10^{-5}$ and $-1.6x10^{-6}$, respectively. Variable velocity will be applied to a vertical border between points (5, -10) and (5, 15) using the following command:

```
applybc("xvel",3.4e-5,"yvar",-1.6e-6,"xlim",4.9,5.1,"ylim",-10.1,15.1)
```

Example 2: Apply Variable Force to a Horizontal Boundary

Figure 2- Apply variable force to a horizontal boundary.

Similarly in Example 1, only **vx** will be in effect and the **vy** value is zero for the horizontal boundary. The x-variation's equation is as follows:

$$V_{mod} = V_0 + vx \times x$$

The force at points (5,10) and (25,10) have velocities of $1x10^6$ and $8x10^6$, respectively. This is how the gradient equation will be expressed:

$1x10^6 = V_0 + vx \times (5)$

$8x10^8 = V_0 + vx \times (25)$

V0 and **vx** can be found to be $7.5x10^5$ and $-3.5x10^5$, respectively, by simply solving the system of equations above. A horizontal boundary from point (5, -10) to (25, -10) will have variable velocity applied to it by the following command:

```
applybc("syy",7.5e5,"xvar",-3.5e5,"xlim",4.9,25.1,"ylim",9.9,10.1)
```

Example 3: Apply Variable Stress to an Inclined Boundary

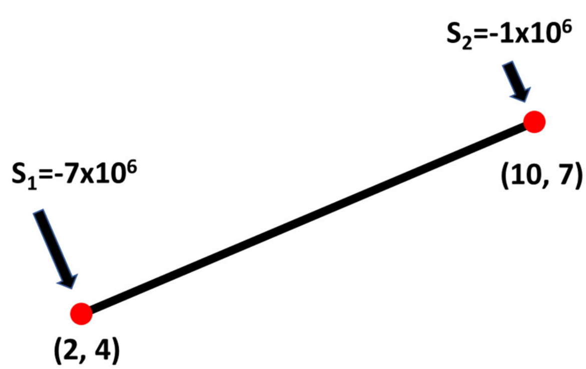

Figure 3- Apply variable stress to an inclined boundary.

The values of **vx** and **vy** together can be utilized to construct a gradient for the applied variable in the case of an inclined boundary. The equations can be made simpler by setting **vy = 0** and estimating the **V0** and **vx** in a manner similar to Example 2, or by specifying **vx = 0** and computing the **V0** and **vy** similarly to Example 1. As seen in Figure 3, let's apply varying stress at the inclined boundary along the line between points (2, 4) and (10, 7). This is the gradient equation that is expressed if we set **vx = 0**:

$$-7x10^6 = V_0 + vy \times (4)$$

$$-1x10^6 = V_0 + vy \times (7)$$

By solving the previously mentioned set of equations, it is possible to determine **V0** and **vy** to be $-1.5x10^7$ and $-2.0x10^6$, respectively. The command below will apply variable velocity to an angled boundary between points (2, 4) and (10, 7):

```
applybc("nstress",-1.5e7,"yvar",2.0e6,"xlim",1.9,10.1,"ylim",3.9,7.1)
```

But if we set **vy = 0** this is how the gradient equation will be expressed:

$$-7x10^6 = V_0 + vx \times (2)$$

$$-1x10^6 = V_0 + vx \times (10)$$

V0 and **vx** can be found to be $-8.5x10^6$ and $7.5x10^5$, respectively. The command using the second method will looks like this:

```
applybc("nstress",-8.5e6,"xvar",7.5e5,"xlim",1.9,9.9,"ylim",3.9,7.1)
```

Similar applied variable stress will be imposed to the inclined border by both approaches.