Surface Process Hazards—Unit 3, Part 1, Physical Factors: What determines whether a slope will fail or stay in place?

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*In this exercise, you will make some calculations to think about the physical factors that contribute to mass movements of Earth materials. As you have discussed in lecture already, any scenario in which the driving force exceeds the resisting force will cause a mass movement.*

# Part 1: Understanding the force of gravity

The force of gravity (FG) is a *mass*-dependent force that is directed downward toward the center of the Earth. The diagram below illustrates a block sitting on a flat surface. In order to calculate the force of gravity (also called the weight, W), we need to know the mass of the block and the acceleration due to gravity (g).

**FG= W= mg**

1. Based on what we’ve just discussed, what is the value and units of g (acceleration due to gravity)?

In the next few questions we will use a simple model to identify and quantify the stresses involved in mass wasting.

2. Consider that the block is 20 m long, 10 m wide, and 10 m tall. In the space below, calculate the volume of the block.

3. We can use the *density* of the material to determine the mass of the block. In the space below, write the equation for density and rearrange it to solve for mass.

4. The density of the block depends on what material the block is made out of. The table below shows the average densities for 3 different kinds of Earth materials. Using these data, calculate the block’s mass if it were made of one of the materials in the table below, and fill in the mass.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Material** | **~Density** | **Mass (kg)** | **Weight**  **(kg m/s2)** | (N) | (S) |
| Sand | ~1.8 kg/m3 |  |  |  |  |
| Limestone | ~2.6 kg/m3 |  |  |  |  |
| Basalt | ~3 kg/m3 |  |  |  |  |

5. Meet with two colleagues who calculated the mass of different materials than you did and complete the table above using their data. Which material resulted in the block with the greatest mass? Which material resulted in the block with the least mass?

6. Do you think that all sand on Earth has the same density? Suggest a factor that could result in variations in the density of a particular Earth material.

7. Using the masses that you calculated above, calculate the weight of each block (W) and record your answers in the table.

# Part 2: Forces on an incline

8. Based on our class discussion, complete the legend below using FN, FS, W, and ****



\_\_\_\_\_\_\_: force oriented perpendicular to the sloping surface

\_\_\_\_\_\_\_: force oriented parallel to the sloping surface

\_\_\_\_\_\_\_: force of gravity  
  
\_\_\_\_\_\_\_: angle of the sloping surface

**W = FG**

**FS**

**FN**

****

**W = FG**

**FS**

**FN**

****

9. In the space below, indicate which force keeps the block from sliding and which force promotes sliding of the block.

**FN:**

**FS:**

10. In the space below, indicate which force is the driving force and which is the resisting force.

**FN: FS:**

11. If the slope angle is 30°, calculate the normal force and shear force of the block of basalt given the equations below. Be sure to include the proper units for force.

**FN = W cos**

**FS = W sin**

Normal force: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Shear force: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Part 3: Understanding the concept of stress

12. As you know from our in-class discussion, stress (force per area) is the pressure under the block of material. Given this, what are the units of pressure (in terms of kg, m, and s)?

Pressure can be measured in Pascals (Pa), bars, pounds per square inch (psi), or as a combination of the units we have been using:

**Atm. Pressure = ~1bar = 100,000 Pa = 100,000 N/m2 = 100,000 kg/m sec2 = 14.5 psi**

13. Please go back to the table in question 4. Using the same block dimensions of 20 m x 10 m x 10 m and a slope angle of 30°, calculate the normal stress and shear stress of blocks of the 3 materials. Write your answers in units of Pascals (kg/ms2) on the table.

Normal Stress (n): holding block in place

Shear Stress (s): pulling block down slope

14. Consider the stresses that you calculated in the previous question. Which stress is greater (circle one):

stress related to the driving force stress related to the resisting force

15. Given your answer to the previous question, should the block slide OR stay in place?

16. Imagine that the slope angle increased to 50°. For each material, calculate the normal and shear stress to determine whether or not the block would slide or stay in place. Explain your answer in the space below.