U. S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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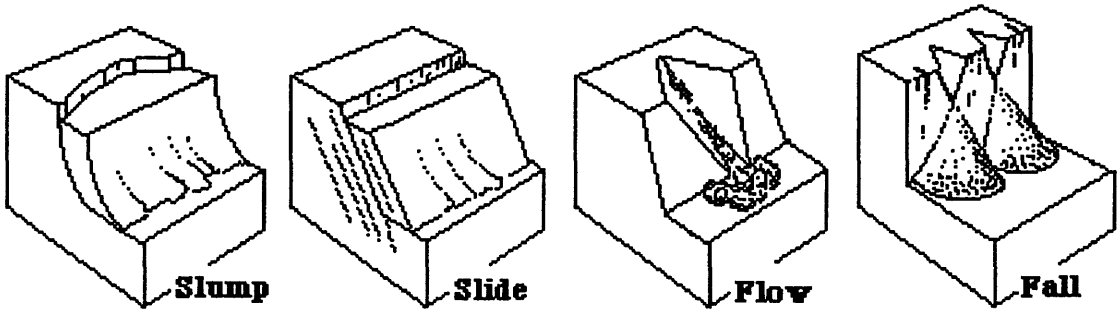
Landslide Effects

By
Tau Rho Alpha*

Open-File Report 93- 278 A



*U.S. Geological Survey
Menlo Park, CA 94025

Description

This report illustrates, by means of computer animation, how four different types of landslides (slide, slump, flow, and rockfall) occur and what type of damage may result*. The report is intended to help students and others visualize what causes landslides and some of the possible results of the landslides. By studying the animations and the paper models, students will come to understand that landslides result from several causes and that the potential consequences of landslides are numerous and serious. Included in the diskette version of this report are the templates for making four paper models, instructions for their assembly, an educators' guide, and animations showing the effects of the four different landslides. The paper version of this report includes everthing except the animations.

Requirements for the diskette version are: Apple Computer, Inc., HyperCard 2.0™ software, and an Apple Macintosh™ computer with high-density drive. If you are using System 7, I recommend using at least 3 MB of RAM with 1.5 MB of system memory available for HyperCard.

Purchasers of the diskette version of this report, which includes all of the text and graphics, can use HyperCard 2.0™ software (not supplied) to change the model (by adding geologic patterns, symbols, colors, etc.) or to transfer the model to other graphics software packages*.

To see the entire page (card size: MacPaint), select "Scroll" from "Go" menu and move the hand pointer in the scroll window. If you are experiencing trouble with user level buttons, select "message" from the "Go" menu. Type "magic" in the message box and press return. Three more user-level buttons should appear.

* In the diskette version (HyperCard stack) additional information can be viewed by clicking on askerisk (*) or **bold type**.

The date of this Open File Report is 5/03/1993. OF 93-278-A, paper copy, 43p. OF 93-278-B, 3.5-in. Macintosh 1.4MB high-density diskette.

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Contents (stack map)

Click on text to go to: *

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Educator's Guide *

Landforms are continuously being modified by weathering and the influence of gravity. The force of gravity may cause the material that makes up the landform to move downslope in a geologic process called **mass movement** (also called mass wasting). Mass movement moves the material downslope where running water can carry it away, eventually to be deposited in the sea. Mass movement and running water form valleys, which are one of the most common features of the earth's surface.

Landslide is a general term which refers to a variety of mass movement processes in which material is transported downslope under the pull of gravity. A landslide generally is a rapid instantaneous collapse of material on a slope. The movement of the material downslope can be rapid, lasting only a few minutes, and large masses of material can be carried downslope with catastrophic results, especially in an urban setting. This instantaneous collapse of material frequently happens in the spring as melting snow or rain adds weight to and lubricates the material to the point where friction is no longer strong enough to anchor the material. All slopes are held in place by the material at the bottom. A landslide can be caused by stream erosion at the base of the slope or by human activities such as the undercutting of the slope, which in effect oversteepens the slope.

This HyperCard stack groups landslides into **rockfall, slide, slump,** and **flow**. In reality, however, most landslides are a combination of one or more of these groups. Landslides can be grouped or arranged as to the make-up of the material in the landslide (earth, rock, and water), the kind of movement the material makes, and the speed of the material as it moves downslope. If the material of the slope is loose rock and soil, it is called **unconsolidated**. The word "rock" is used when landslides are composed of hard rock or consolidated material. Landslides composed of unconsolidated material are described by words like "debris flow," "mudflow," and "earthflow." Slide is a term that describes consolidated material that moves down a well defined surface such as a bedding plane, joint, or fault that is parallel to the slope of the landform.

A slump is a variety of a slide, and the surface that the landslide moves on is curved or bowl shaped. When water and unconsolidated material move downslope as a fluid it is called a flow. Flows can happen when dry consolidated material is moved downslope lubricated by air. Some landslides move down a slope at speeds over 161 kilometers per hour (100 miles per hour). Other landslides move so slowly that the motion cannot be observed: when this happens it is called **creep**. As a result of frost action and other forms of weathering, rocks and boulders fall from cliffs, creating what is called a rockfall. These rocks and boulders may form cone-shaped deposits at the base of the cliffs that are called **talus cones**.

A slide is any cohesive block of consolidated rock or other material that has moved downslope on a surface of rupture (plane of slip). When slides occur on rock strata that are inclined parallel to the slope, or where joints and fractures exist parallel to the slope, the surface of rupture beneath the slide block is planar and the cliff where the block broke away has a fairly straight edge. The slide block may rotate so the back of the block is tilted toward the surface of rupture, but such rotation is generally much less than in a slump (see slide animation, p. 42).

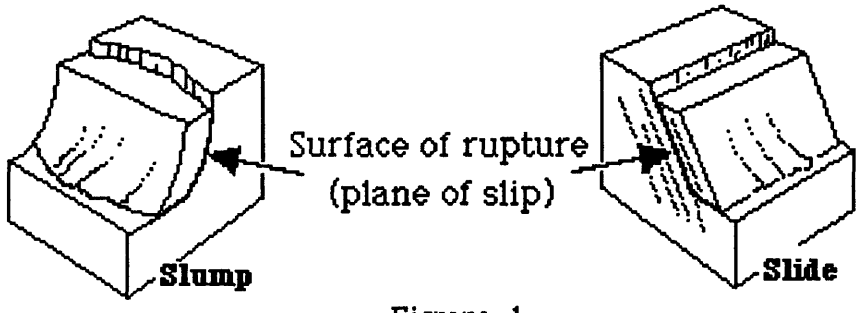
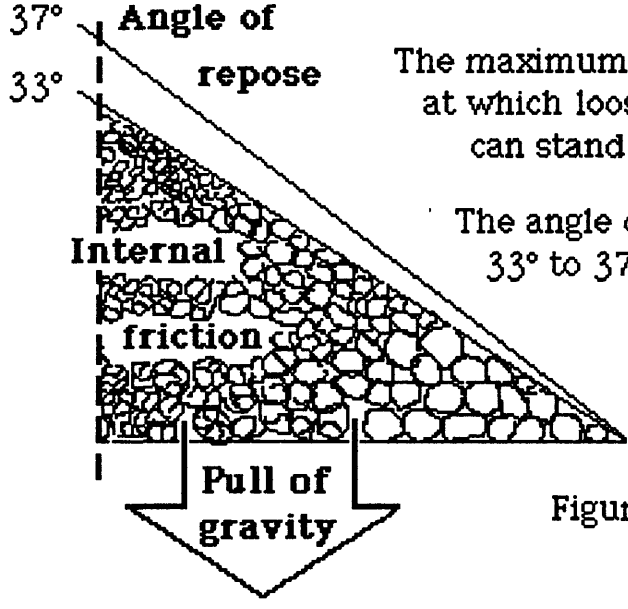


Figure 1

A slump is a type of slide in which a block of cohesive soil or consolidated rock has moved as a unit down a curved slip surface. The result is a cliff where the slump block broke away moved downslope, and came to rest lower down. The surface of rupture (**plane of slip**) beneath the slump block is generally bowl shaped; as a result, the headwall is a crescent-shaped cliff, and the slump block is rotated so the back of the block is tilted toward the surface of rupture (see: slump animation page 42)

Flows include earthflows and debris flows, mudflows, and even air-lubricated rock flows. Flows happen when the cohesion of the material that makes up the slope breaks down and the material starts to become a fluid. If oversteepened, unconsolidated material has a component of clay, the clay becomes very slippery when wet, and, with the added weight of the water, a landslide may be triggered. Earthflows occur on smooth slopes independent of gullies, ravines, or stream channels and are relatively slow moving. A debris flow is unconsolidated material combined with a large amount of water that follows an existing gully or stream channel. With heavy rain or rapid snow melt in semiarid areas, large amounts of unconsolidated material are washed into stream channels. There is generally little or no vegetation to hold the unconsolidated material together, and a rapid flow of water, mud, soil, vegetation, rocks, and boulders cascades down a channel destroying everything in its path (see flow animation, p. 42). On active volcanoes, there is a special type of debris flow that consists mostly of loose, unconsolidated volcanic ash and is triggered by runoff from snowmelt; this type of flow is called a **lahar**.

A rockfall consists of individual boulders and rocks that have broken loose from a cliff and, pulled by gravity, fall, bounce, or roll downslope and form talus cones or talus slopes. Such erosion results from weathering, especially frost action in which water freezes and refreezes and wedges boulders and rocks free from the cliff. As rocks roll, bounce, or fall from the cliff, they are funneled through ravines and gullies. The boulders have more momentum than the smaller rocks and come to rest at the base of the talus slope (see rockfall animation, p. 42). The surface of the talus cone slopes at an angle of about 35°. This angle at which loose rocks and boulders will lie at rest is called the **angle of repose**. At steeper angles, the loose rocks and boulders will continue to move downslope until they come to rest on a slope at or below the angle of repose.



The maximum angle of slope at which loose material can stand.

The angle of repose varies from 33° to 37° for different materials.

Figure 2

The following glossary will help you get acquainted with some of the terms associated with landslides.

angle of repose The maximum slope or angle at which a material such as soil or loose rock remains stable.

creep The slow, more or less continuous downslope movement of soil and rock materials under the pull of gravity.

flow A mass of loose material, usually mixed with water, moving as a semifluid downslope.

lahar A debris flow or mudflow of volcanic material.

landform Any physical feature of the Earth's surface having a characteristic shape and produced by natural causes.

landslide A general term describing a variety of mass-movement processes in which material is transported downslope under the pull of gravity.

mass movement or masswasting The gravitative transfer of material down a slope.

plane of slip or surface of rupture The surface where the soil and rock break away from the landform.

rockfall The free falling or rolling of detached rock pieces down a cliff.

slide Material moving as a unit downslope along a discrete surface of slip.

slump Material moving as a unit downslope along a curved surface of slip (concave up). (Slump is a special case of slide.)

talus cone A conical pile of rock material of any size derived from and lying at the base of a cliff.

unconsolidated material Material consisting of loose particles that are not cemented together.

Educator's Guide

Here are a few questions for further study to help you think about landslides.

1. What is the meaning of the term "slope"?

2. How do steep slopes and cliffs form in nature?

3. What is "mass movement"?

4. Do landslides occur on the ocean floor?

5. Investigate some historic landslides and report on them.

6. What human activities can cause landslides to happen? How?

7. Each of the paper models displays neighborhoods. What are some of the problems or hazards the neighborhoods have to face living so close to a landslide or potential landslide.
Discuss possible solutions to these problems with your class.

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Additional Models

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Additional Models Cont.

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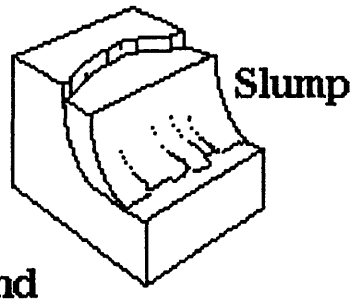
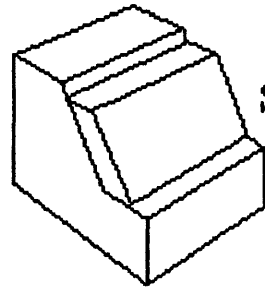
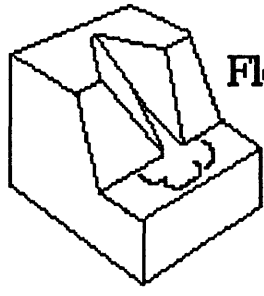


Slump



Slide

Patterns for paper models and instructions for assembly



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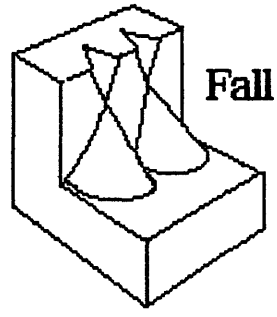

Fall

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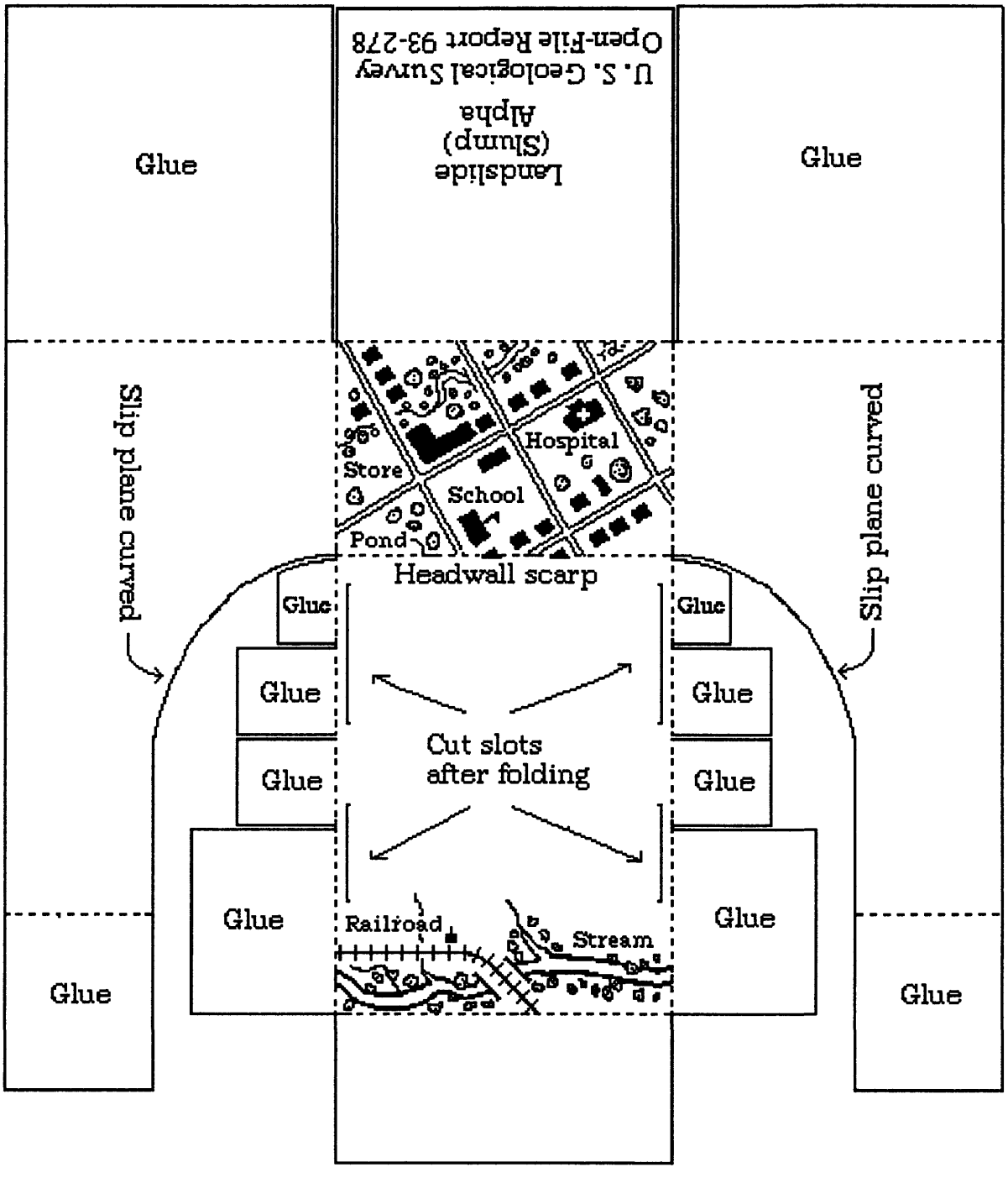
Slump Base



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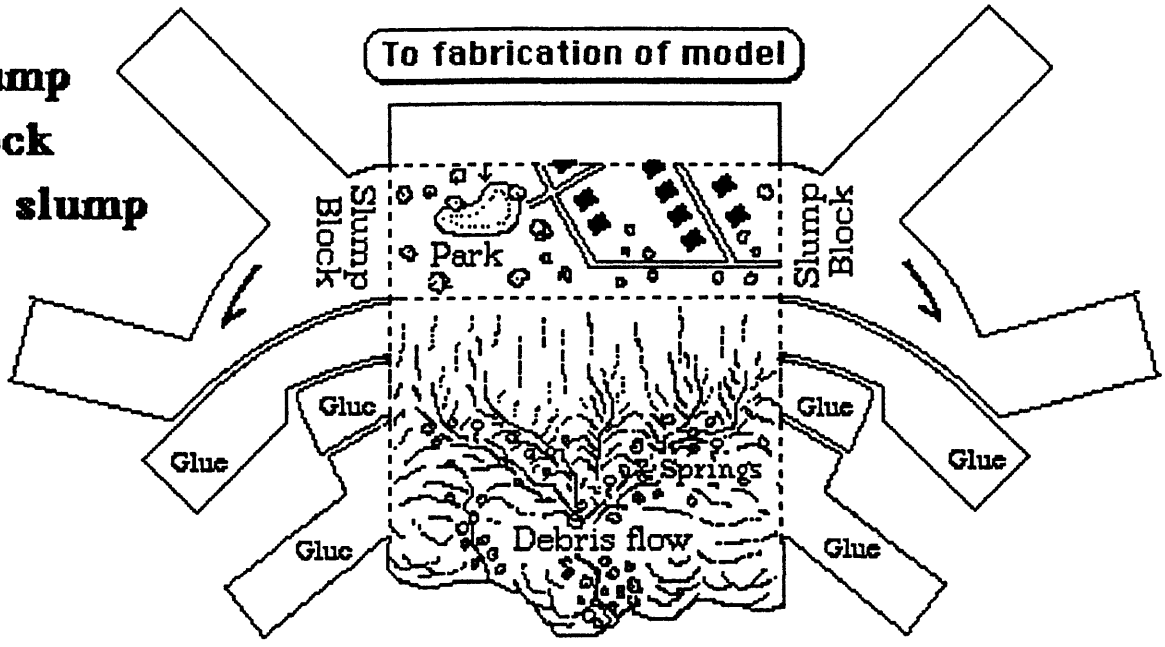
Slump block for slump



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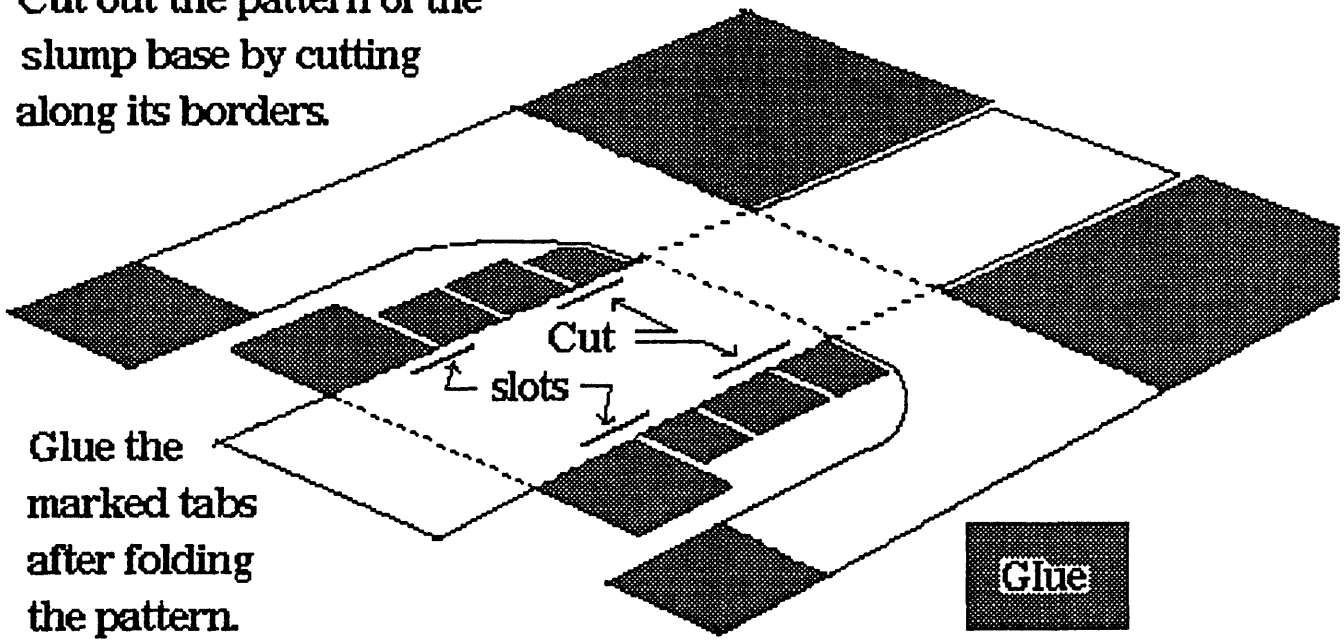

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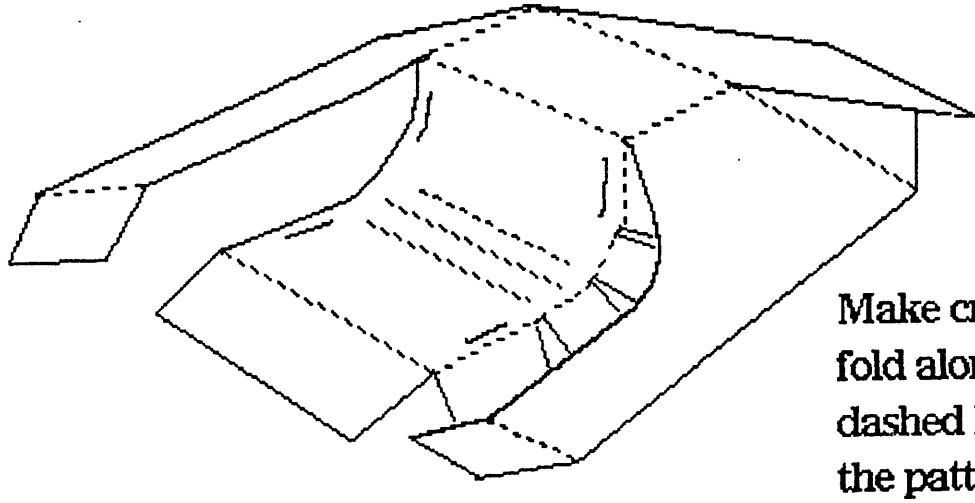

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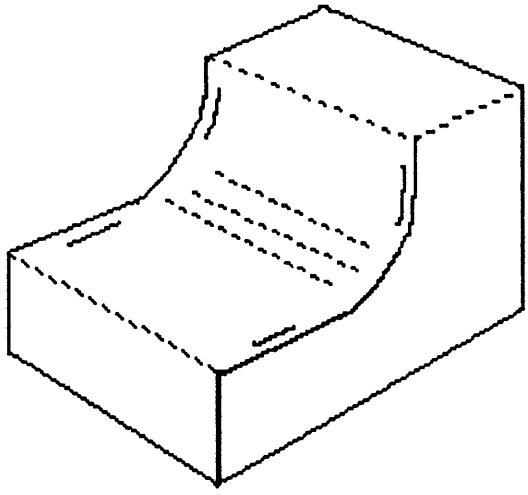

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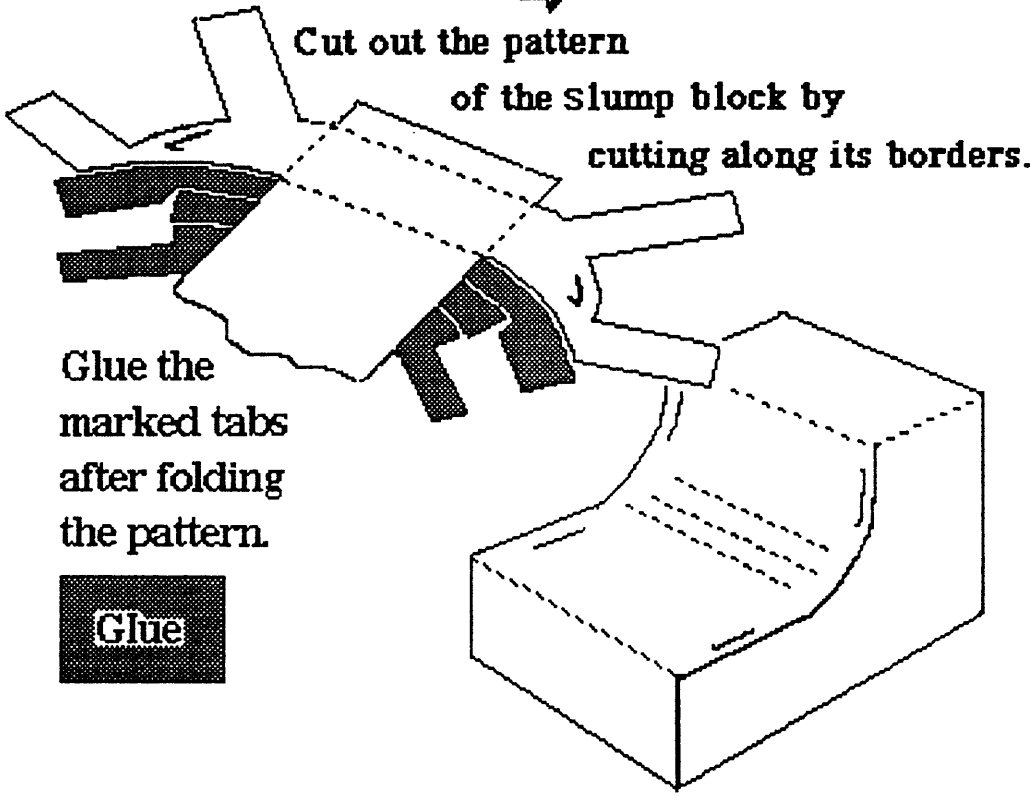
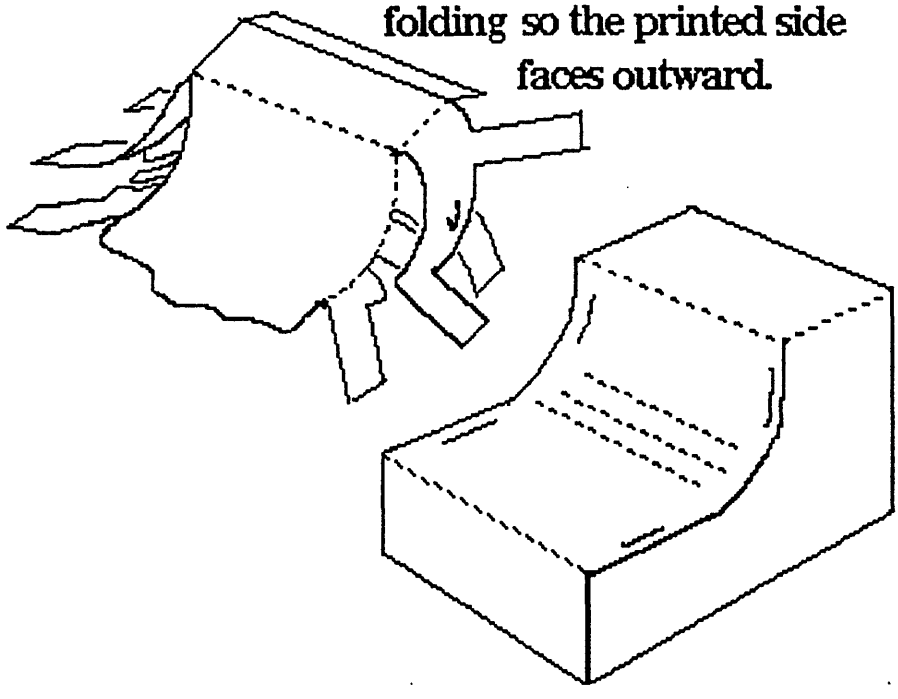


Cut out the pattern of the slump block by cutting along its borders.

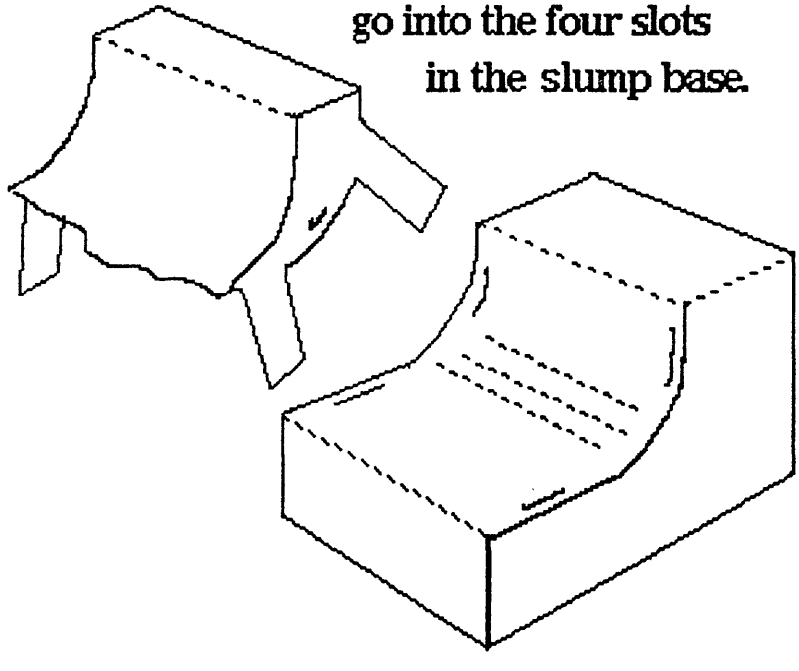
Glue the marked tabs after folding the pattern.

Glue

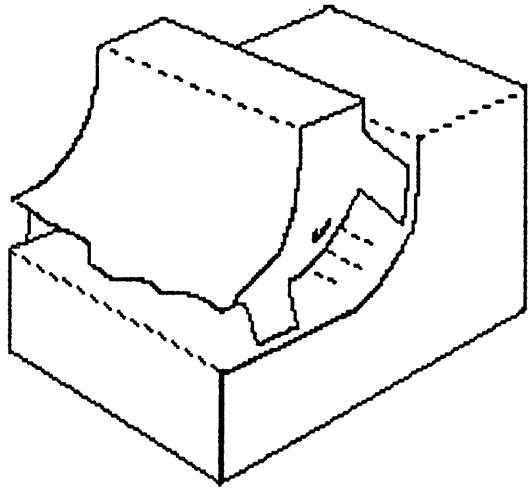
Make creases and fold along the dashed lines within the pattern, folding so the printed side faces outward.



After gluing, the four tabs go into the four slots in the slump base.



Assemble the slump block to the base.



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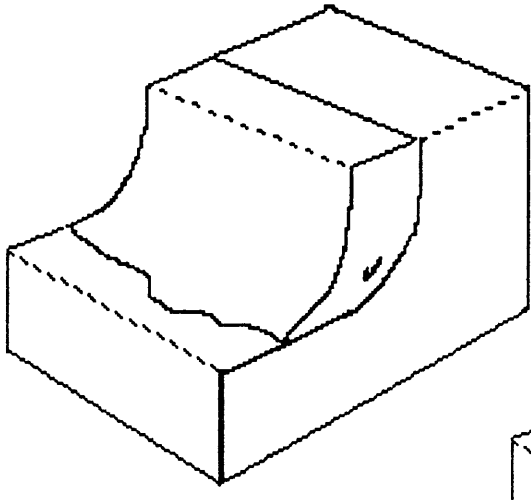

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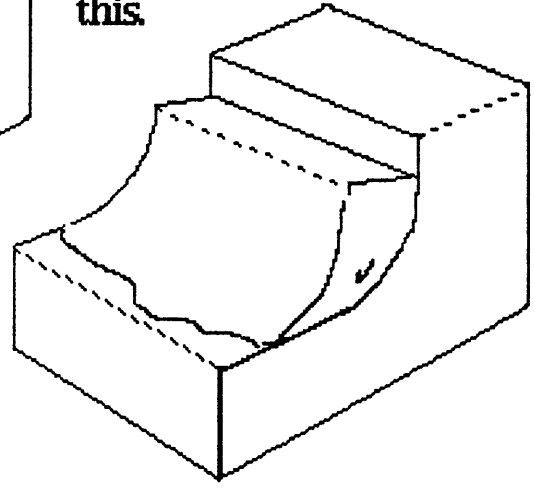

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To Slide Block
To fabrication of model

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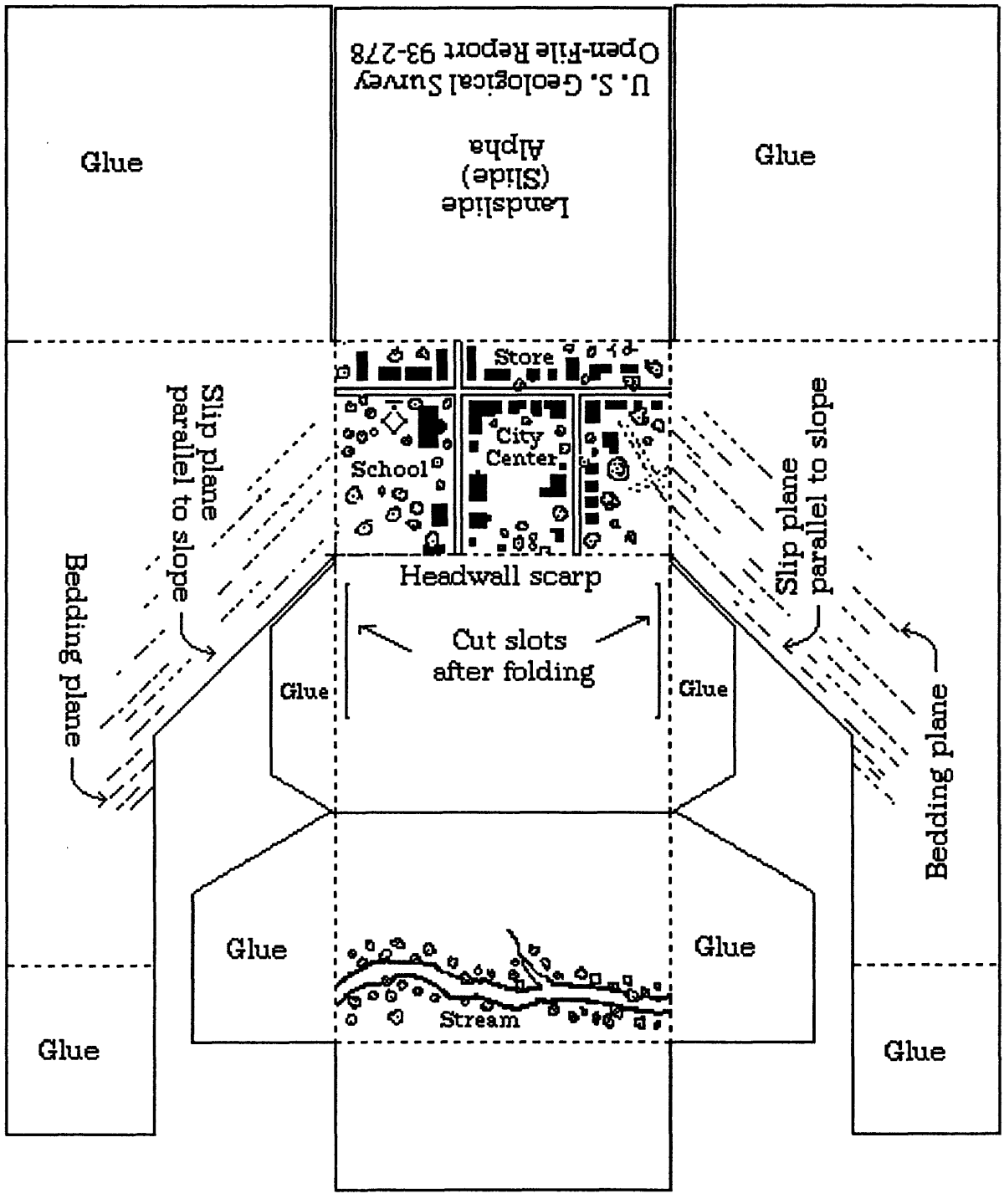

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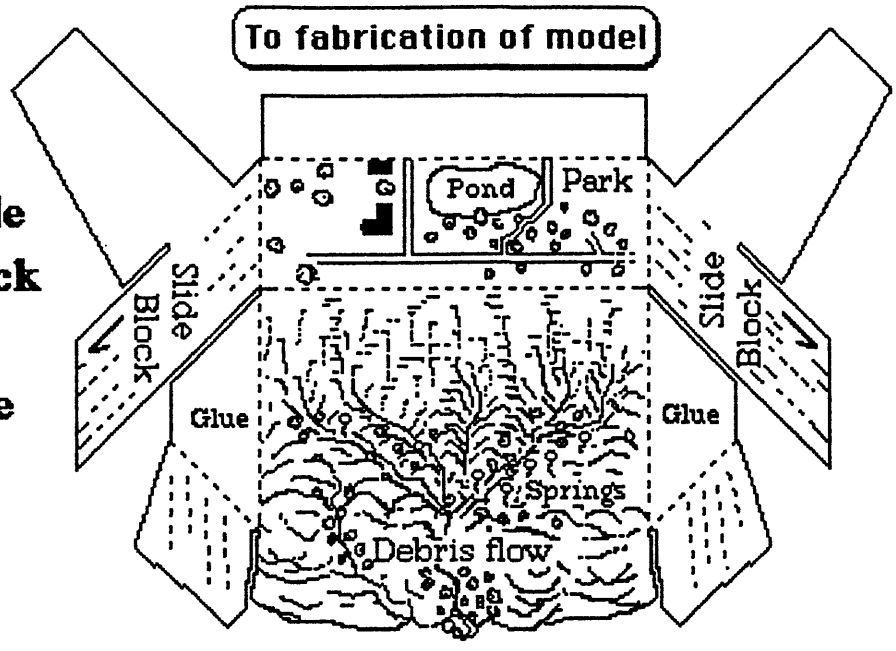

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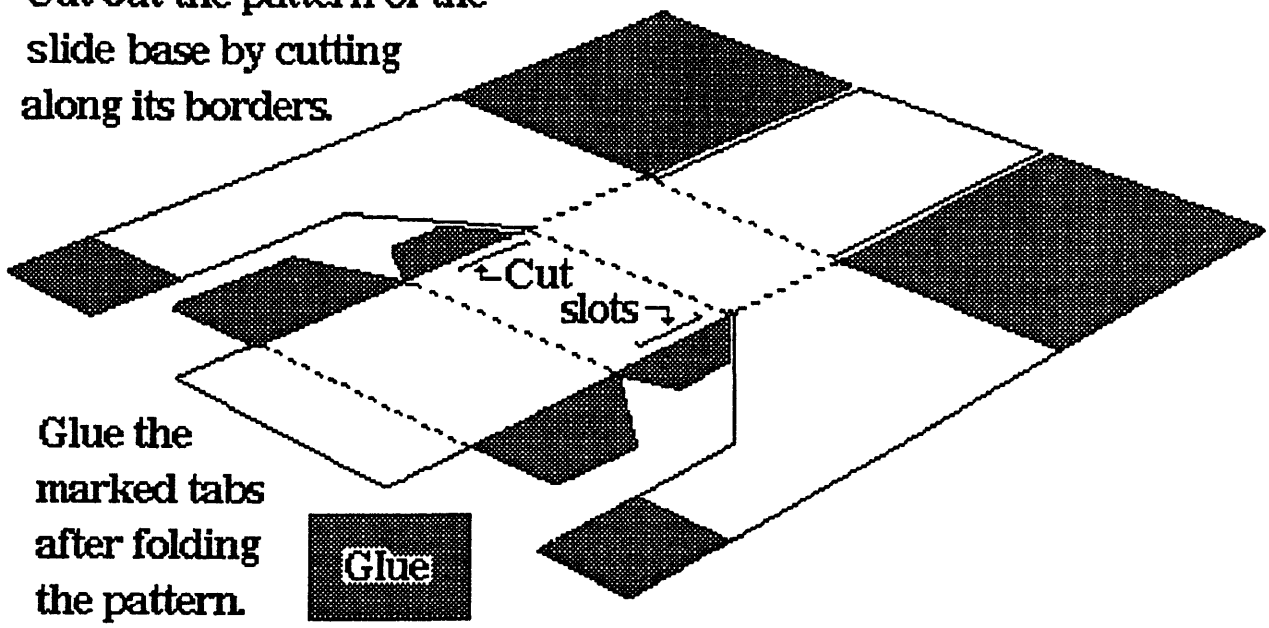

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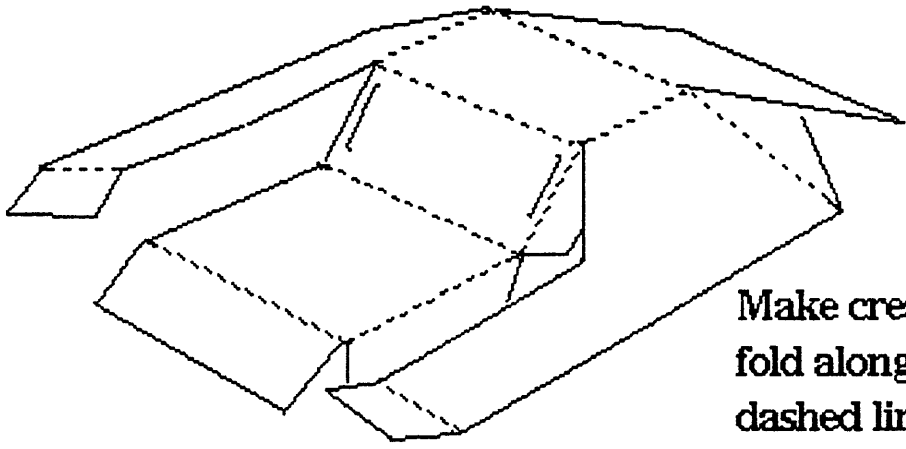

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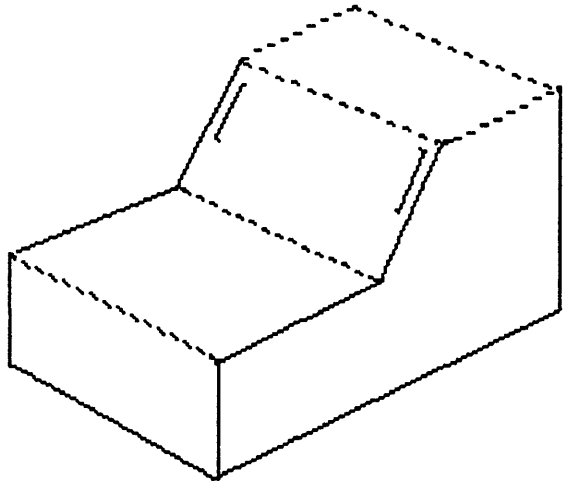

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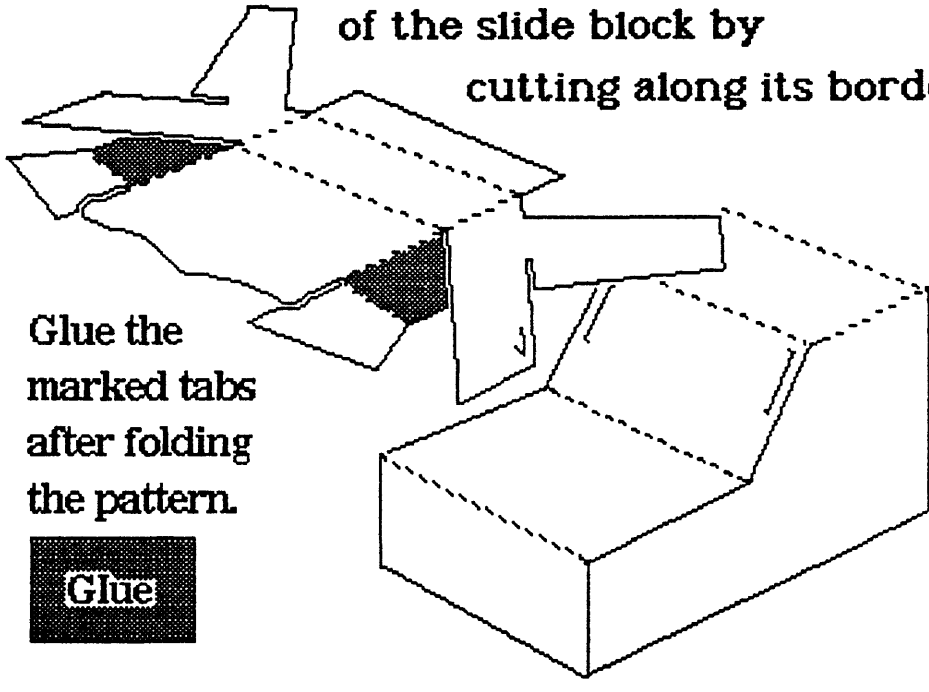

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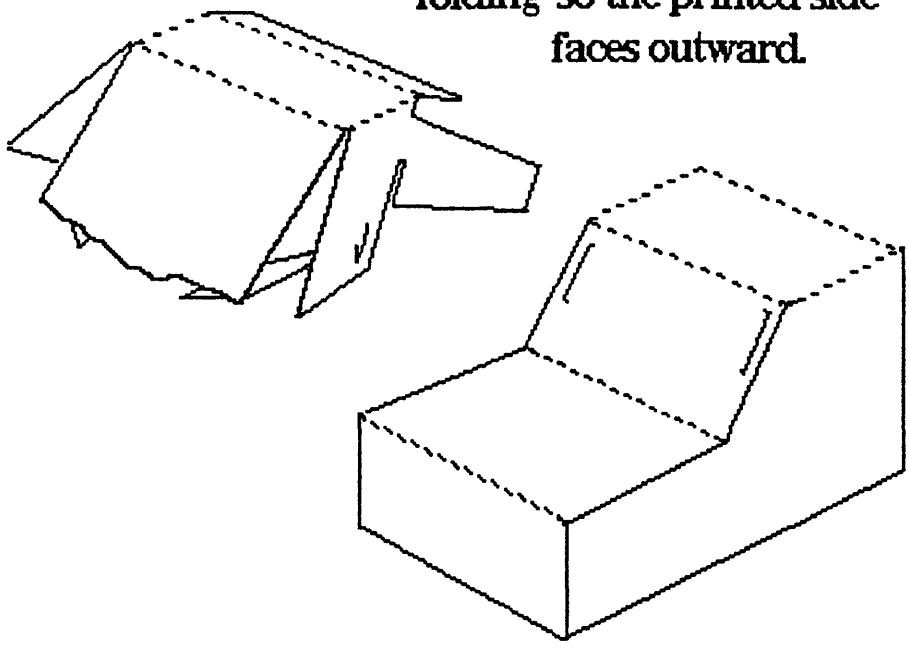

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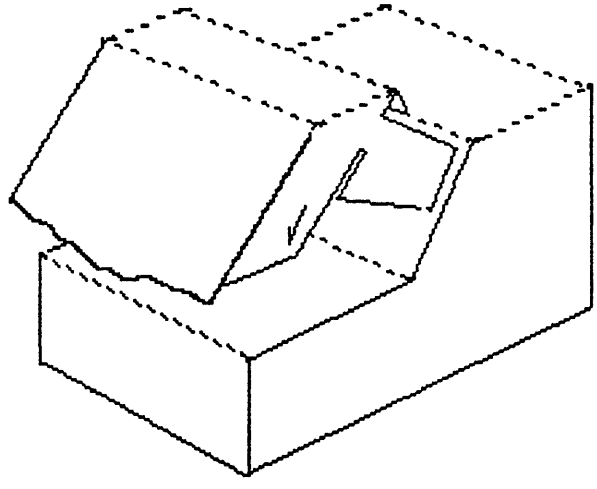

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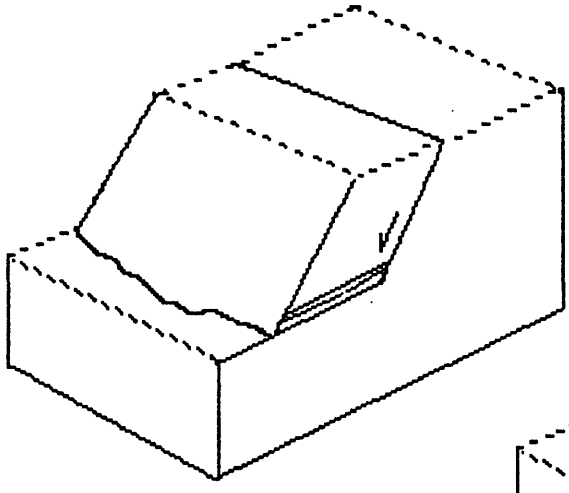

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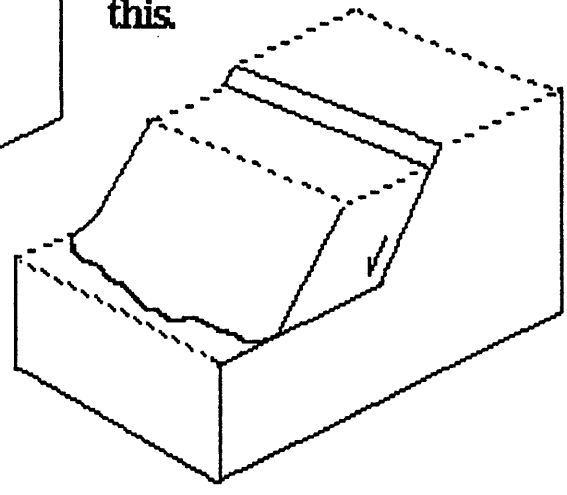

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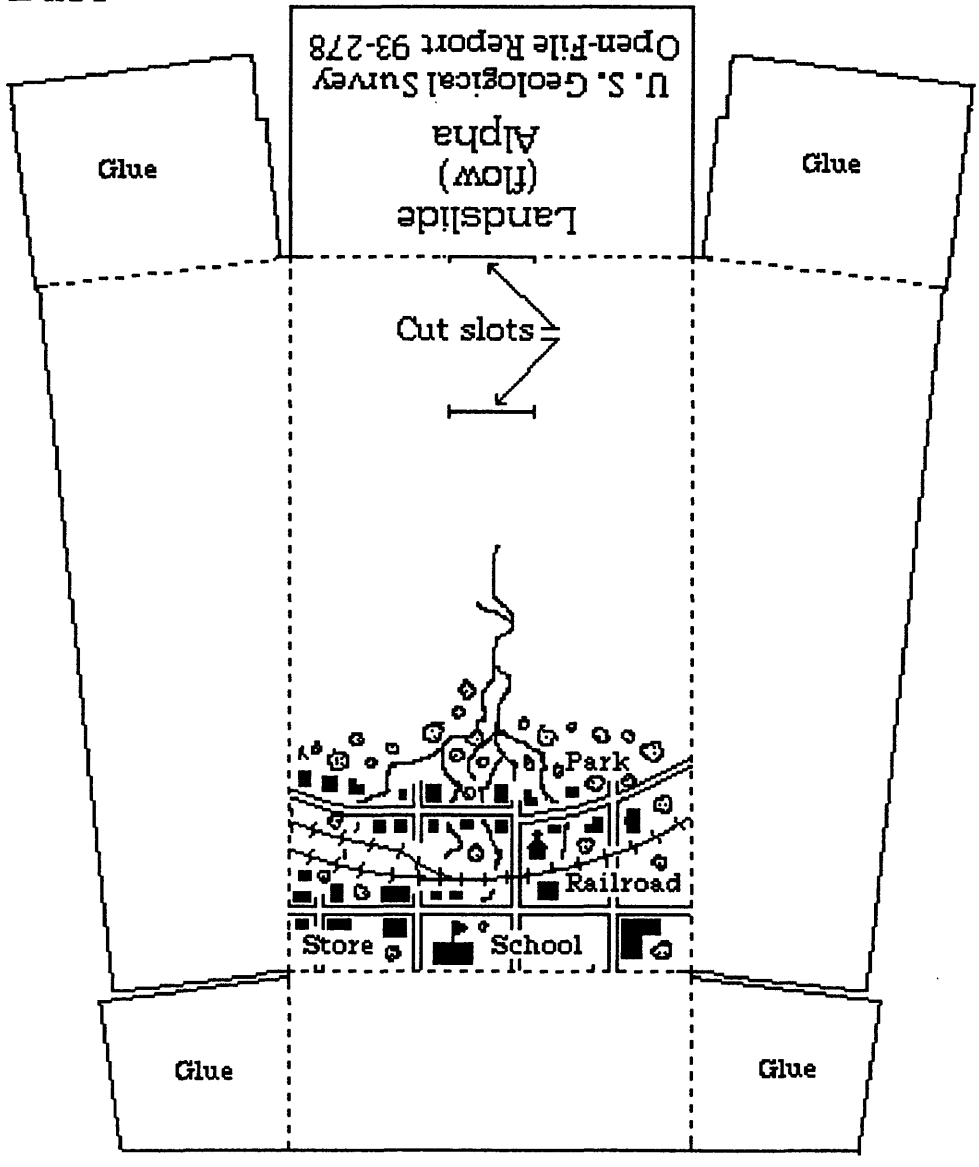
Flow Base



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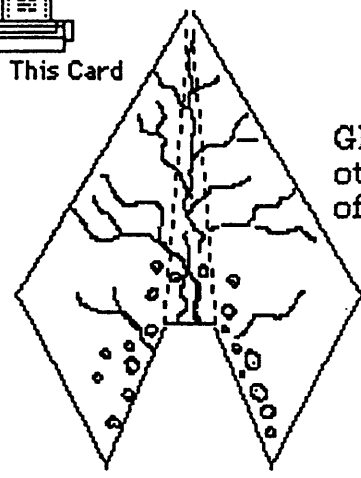

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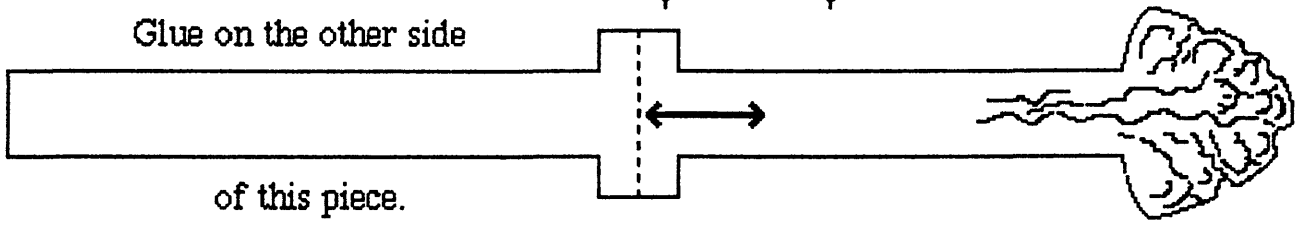

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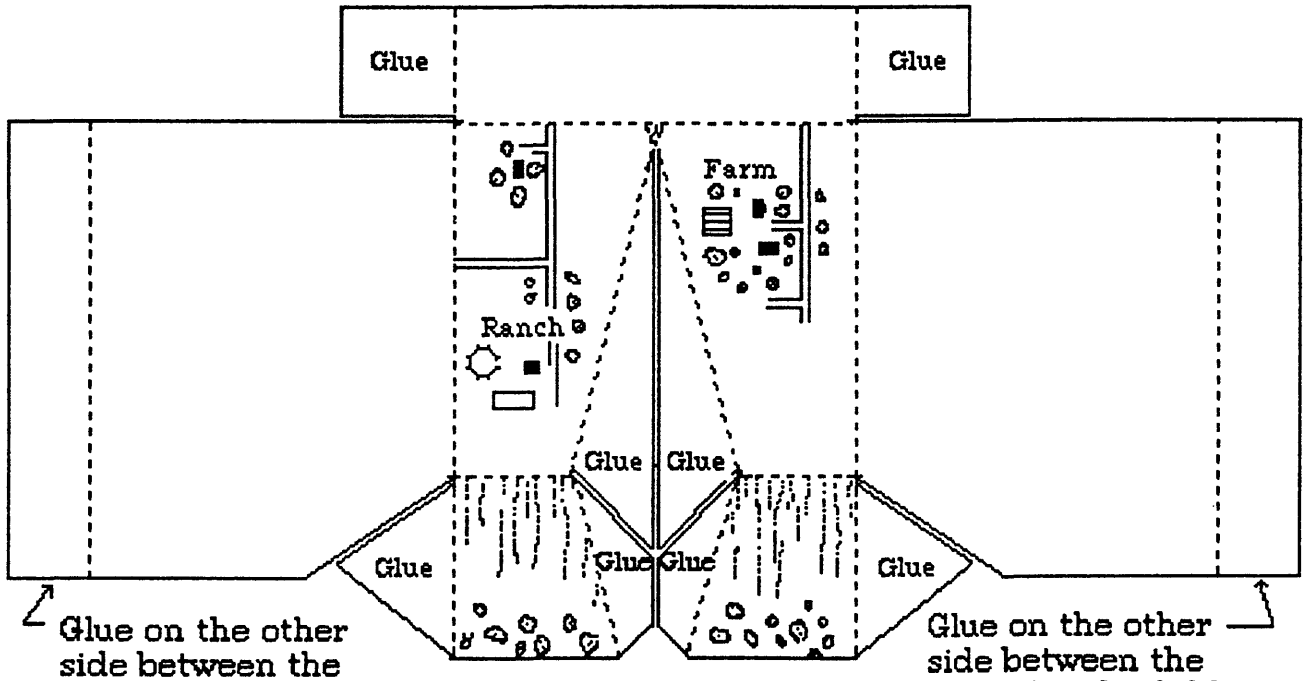

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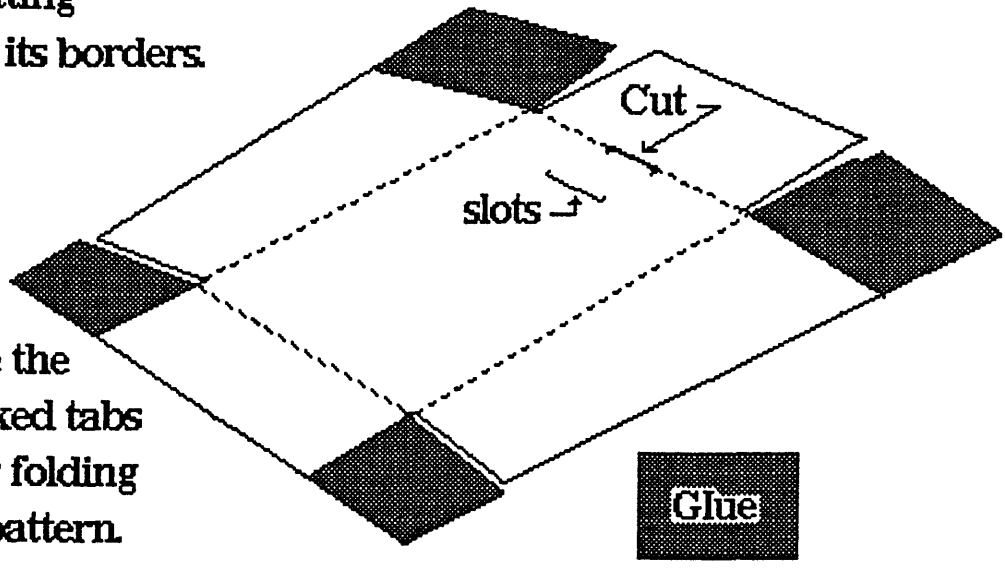
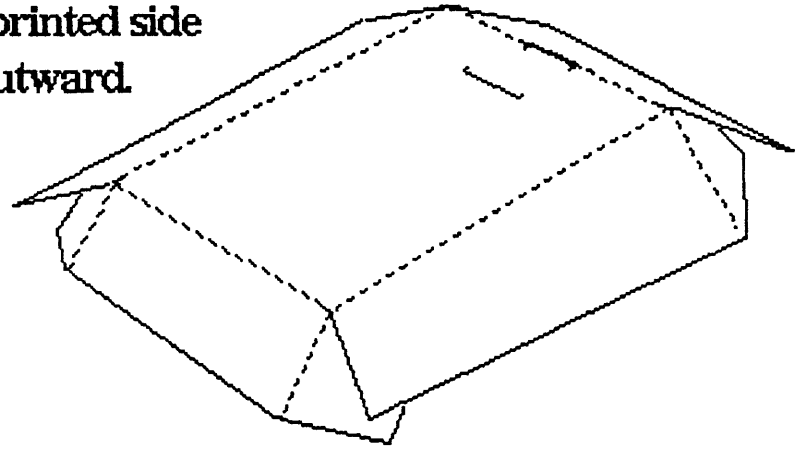
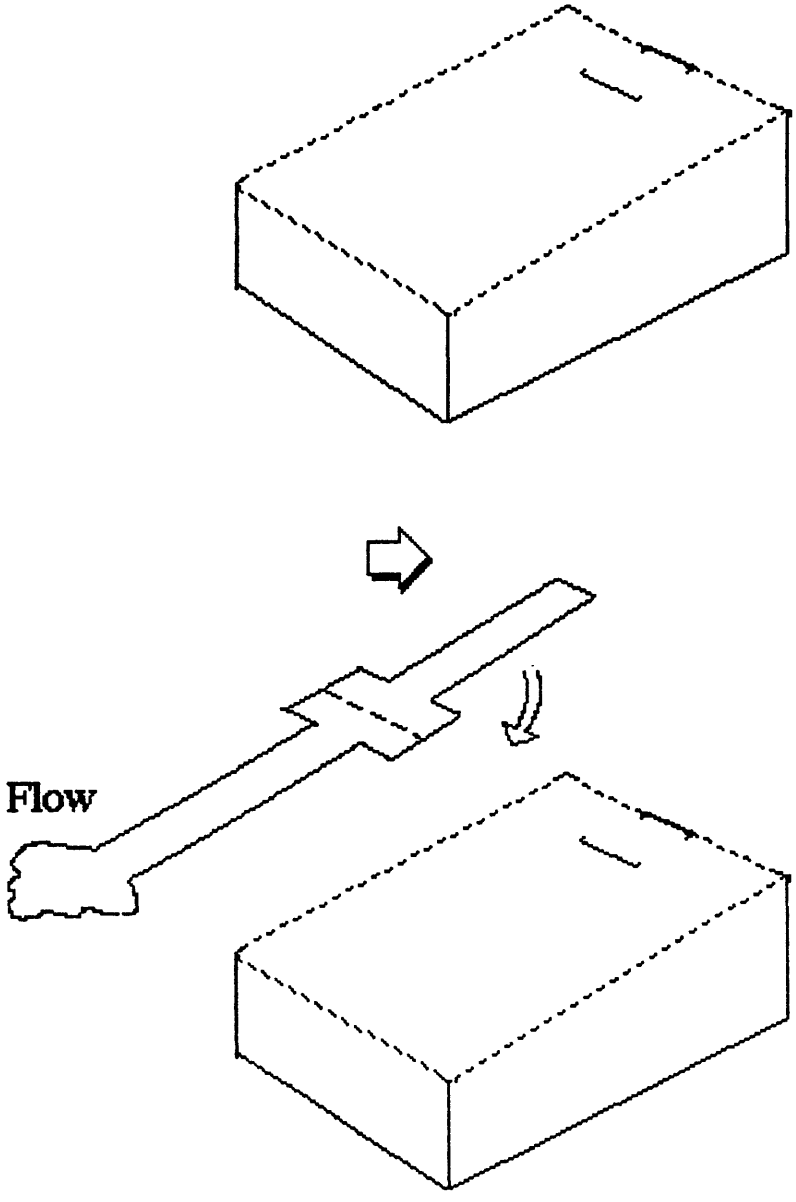


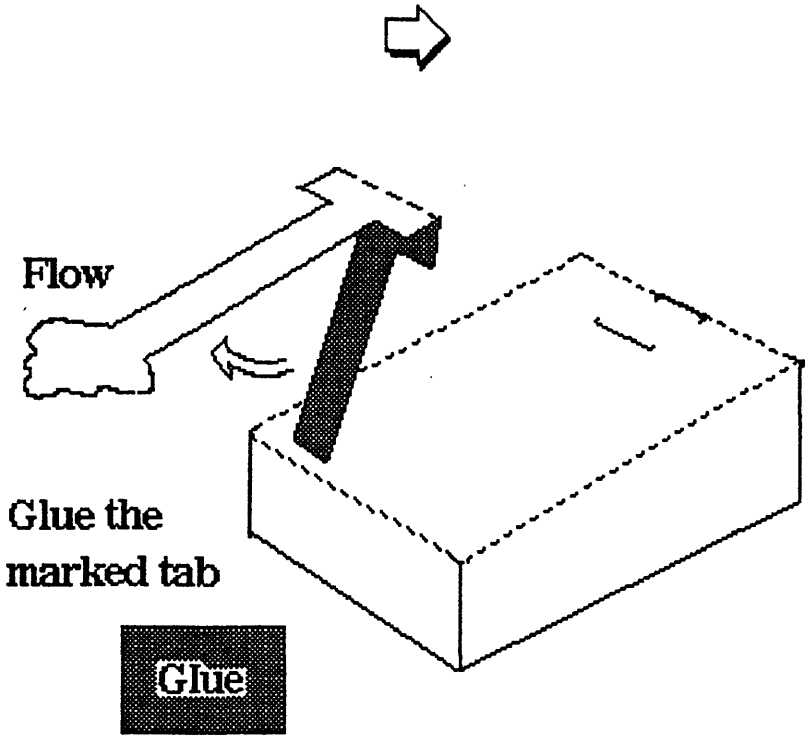
Glue the marked tabs after folding the pattern.

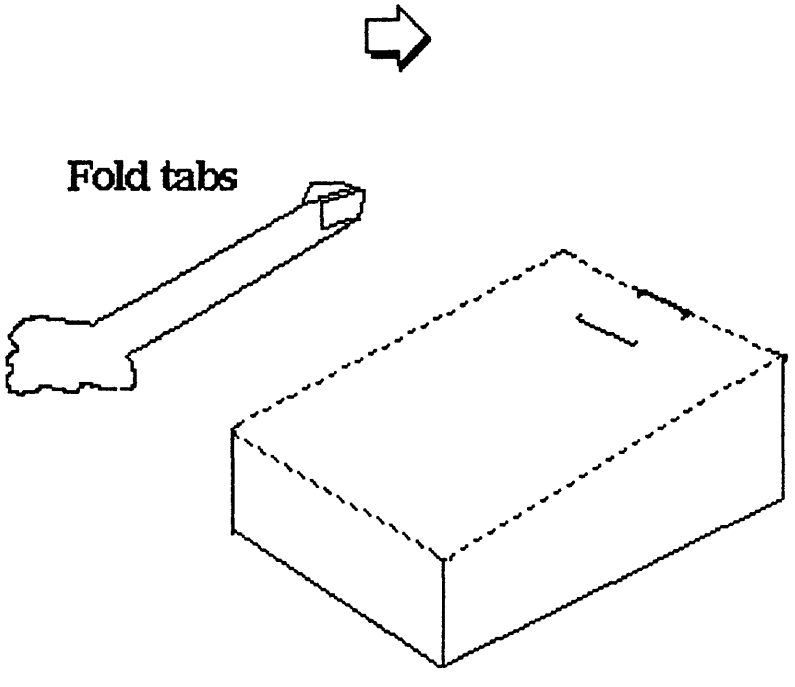
Make creases and fold along the dashed lines within the pattern, folding so the printed side faces outward.

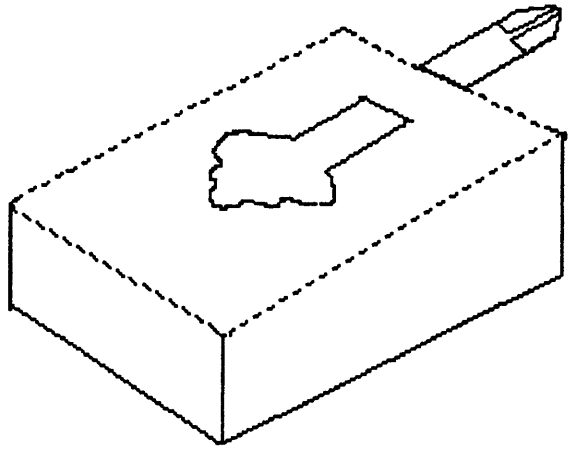


The assembled flow base should look like this.

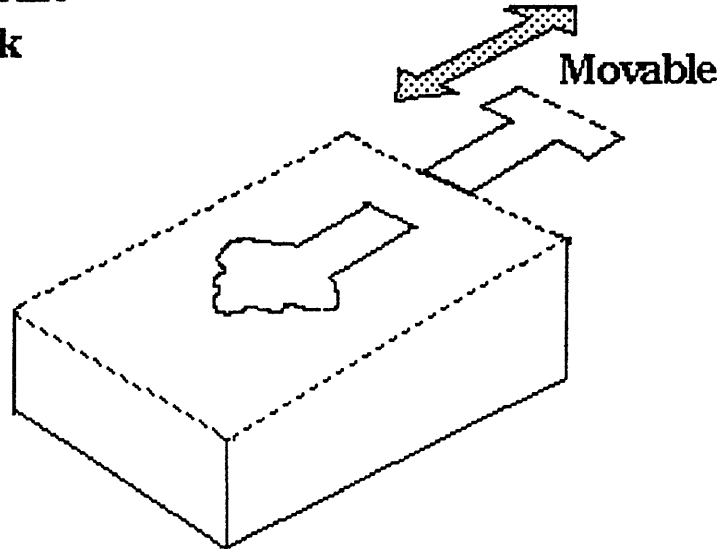


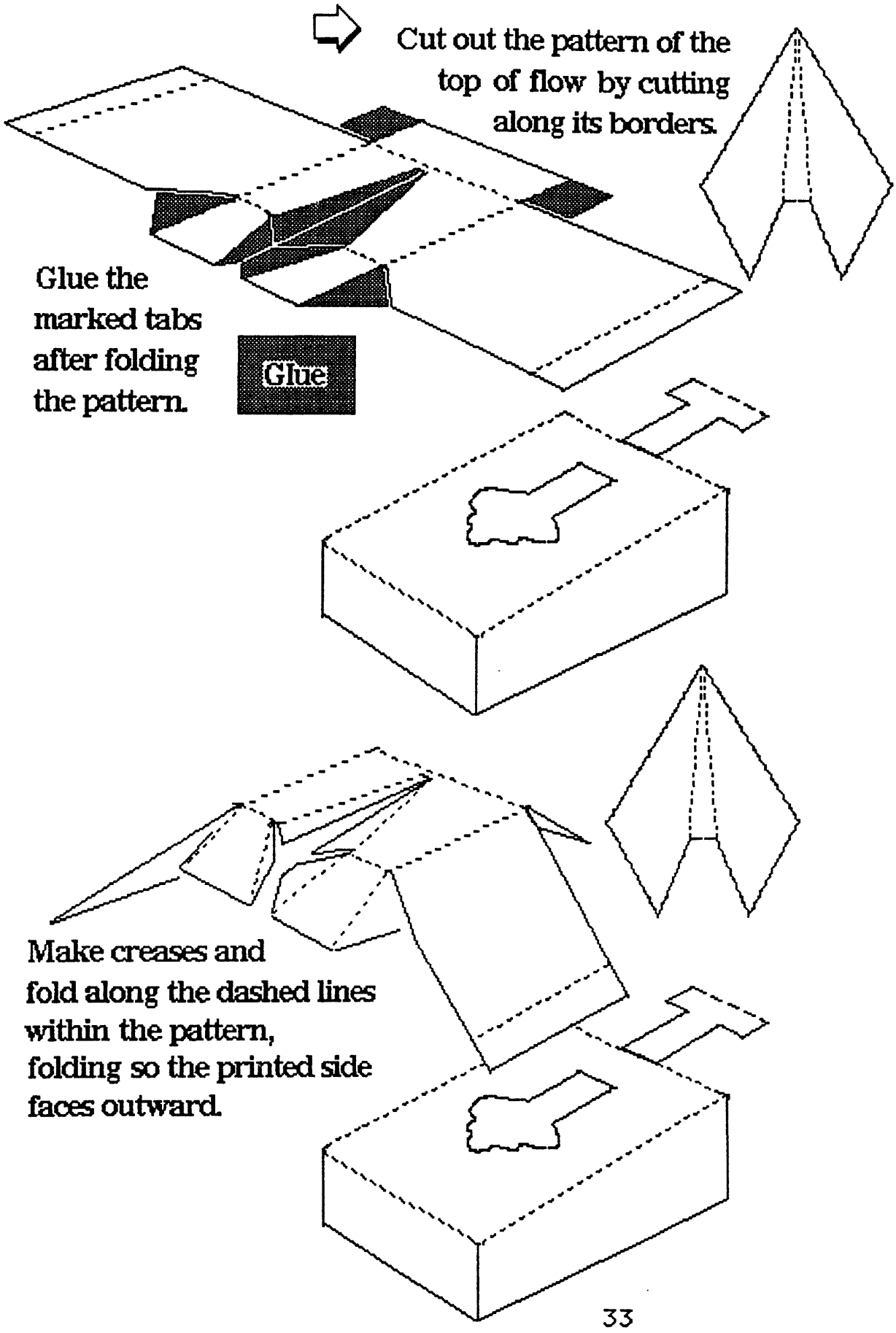

Flow
Glue the
marked tab
Glue

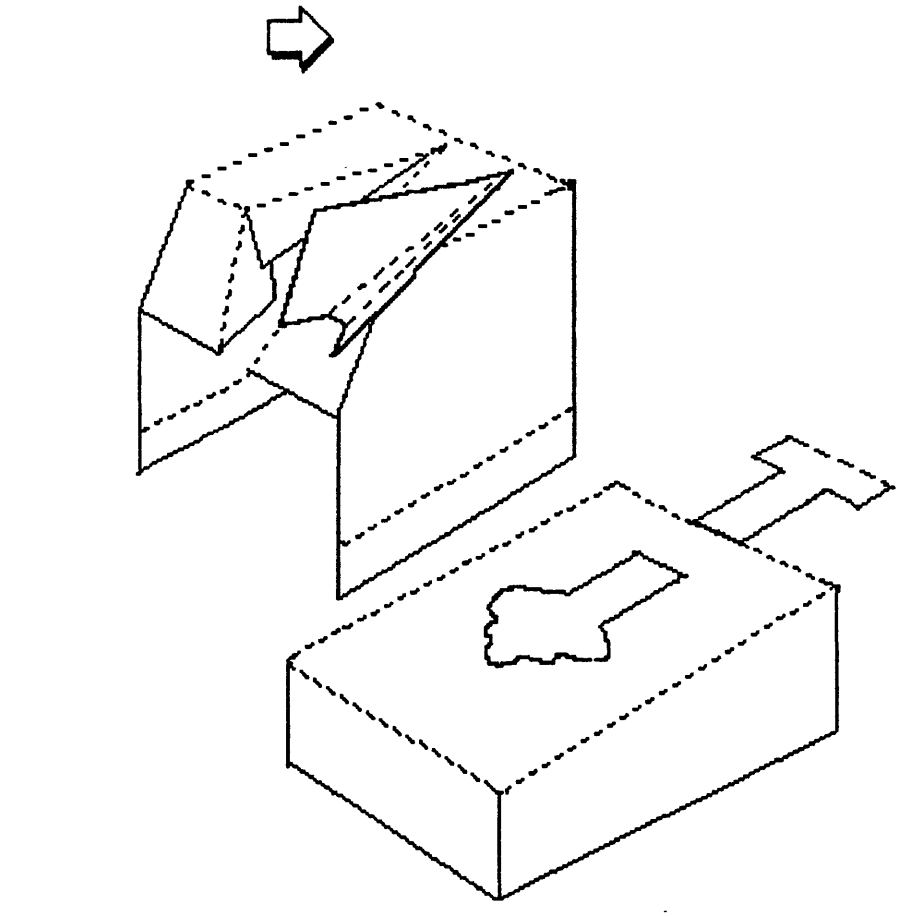

Fold tabs

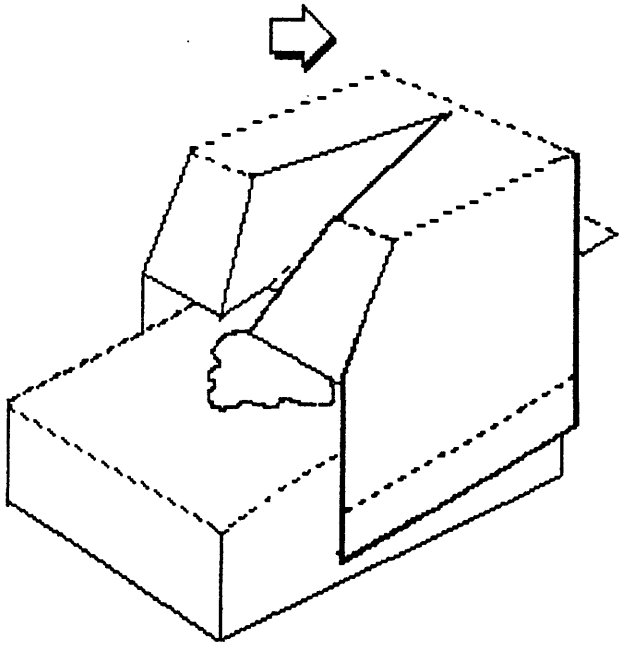


The assembled flow and base should look like this.

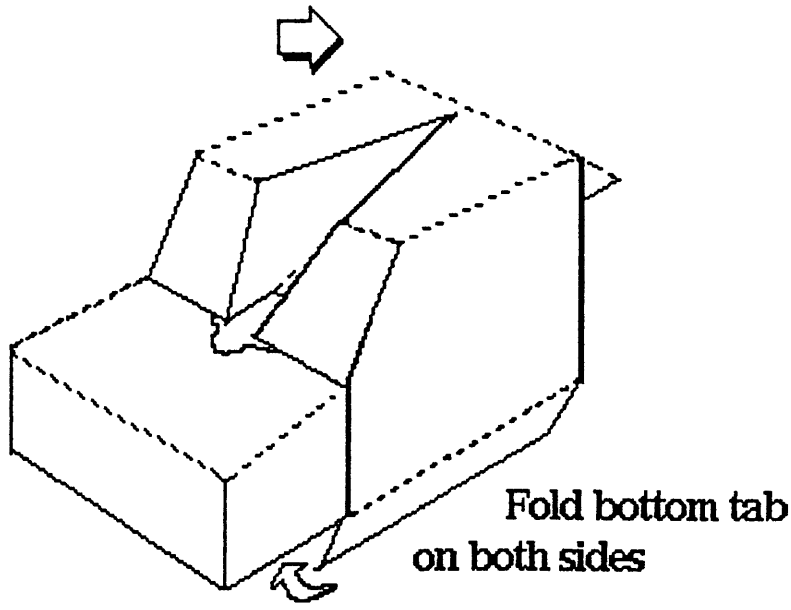



Cut out the pattern of the top of flow by cutting along its borders.
Glue the marked tabs after folding the pattern.
Glue
Make creases and fold along the dashed lines within the pattern, folding so the printed side faces outward.

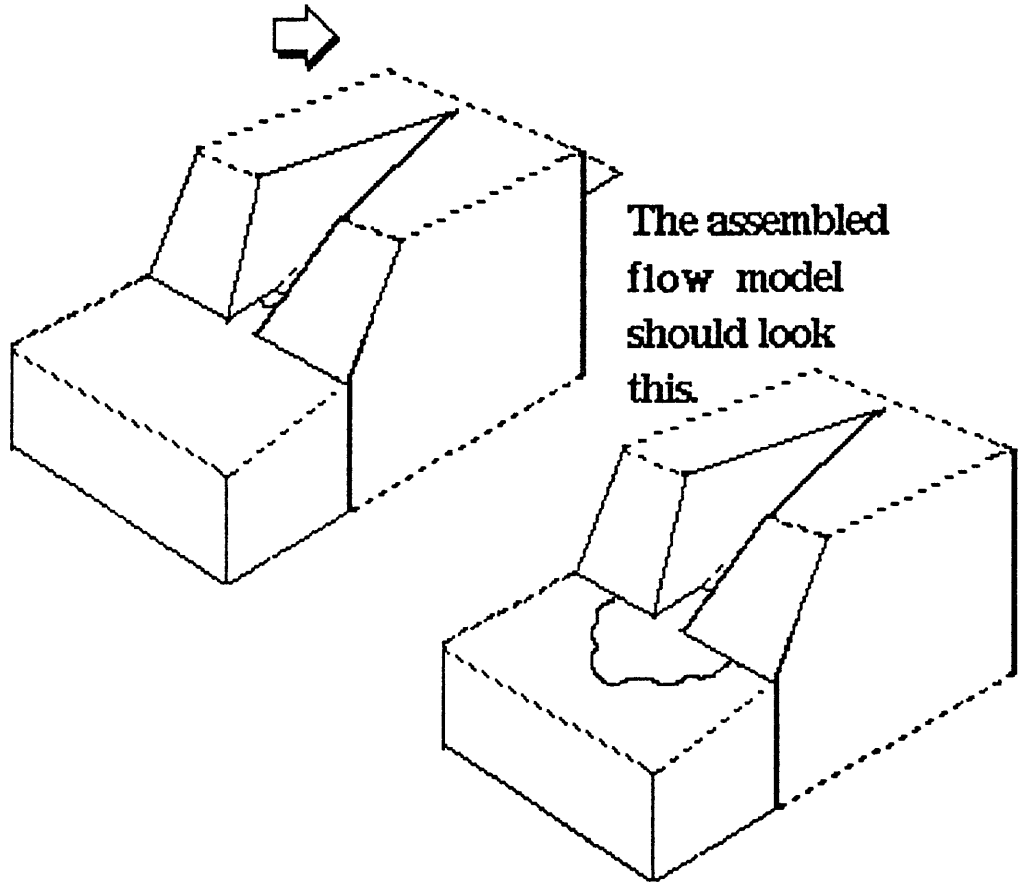




Landslide1993

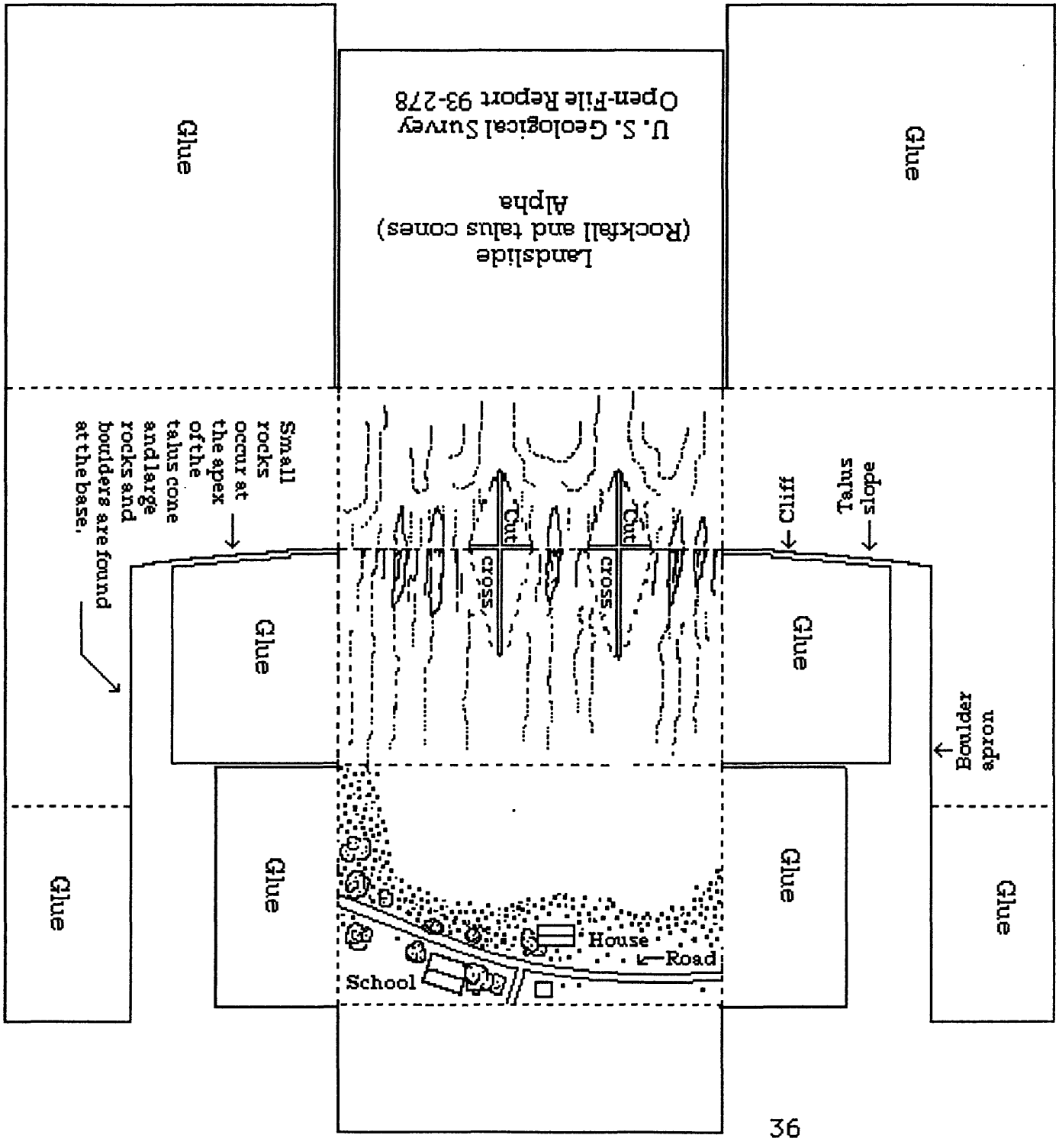


Landslide1993



To Landslide Patterns
To talus cones
To fabrication of model
Print This Card

Rockfall Base



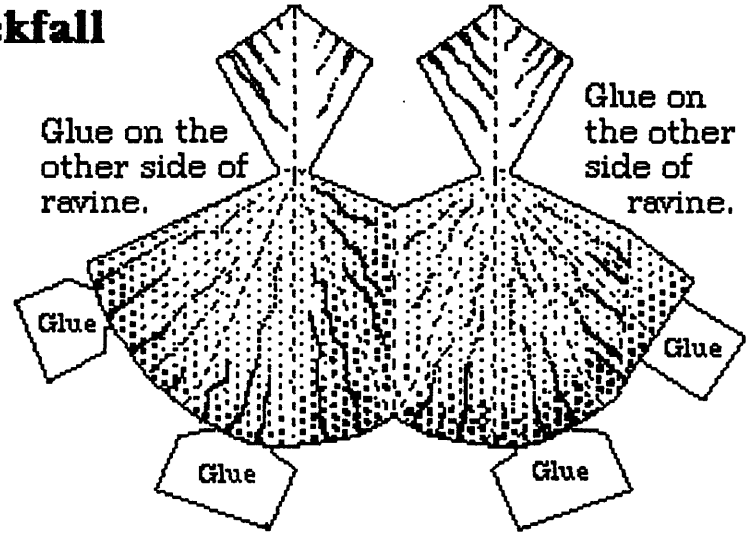
To Landslide Patterns

Print This Card

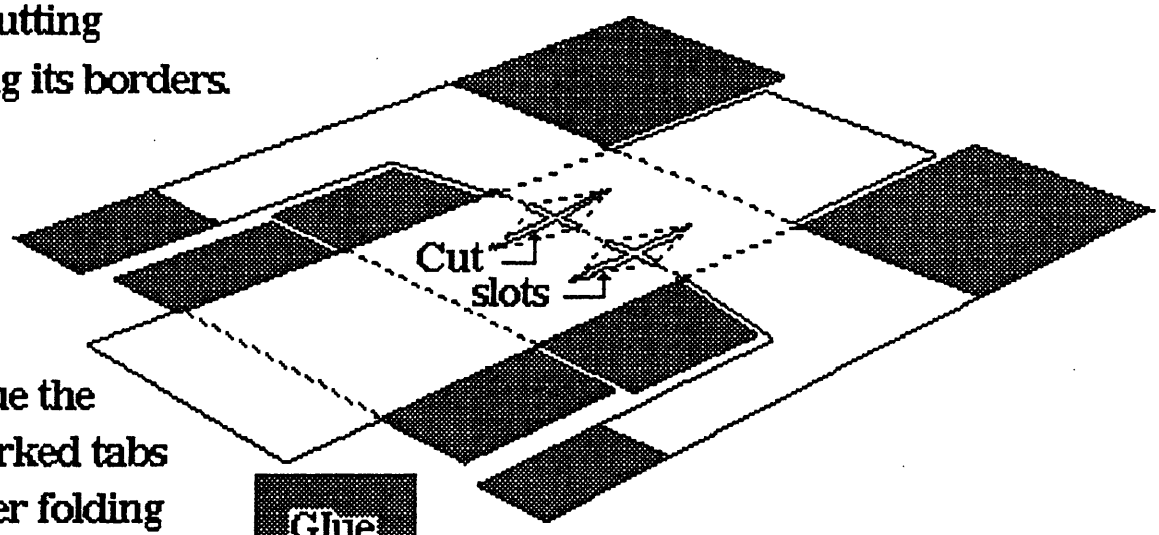
To rockfall base

To fabrication of model

Talus cones for rockfall



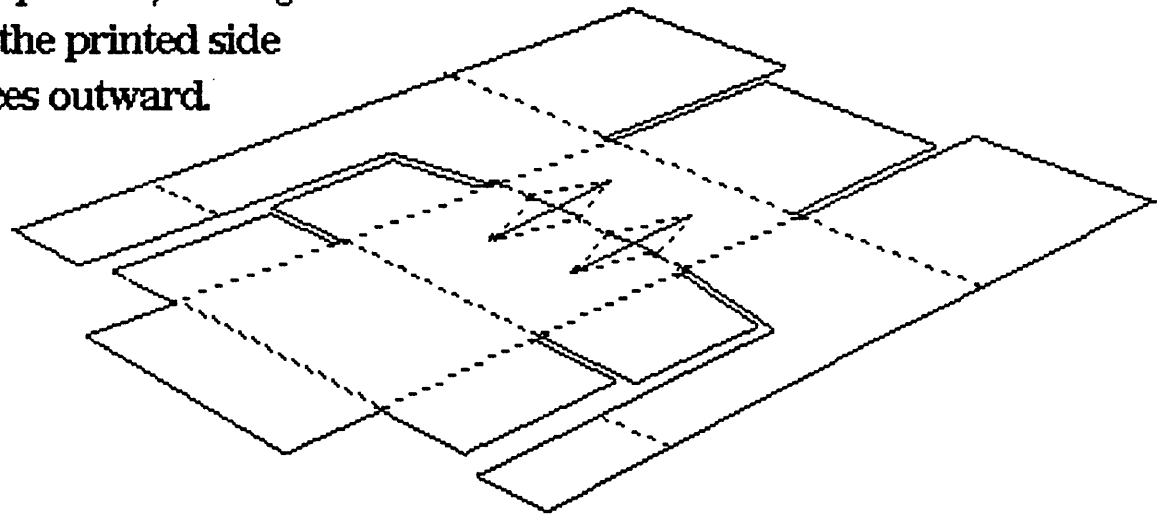
Cut out the pattern of the rockfall base by cutting along its borders.

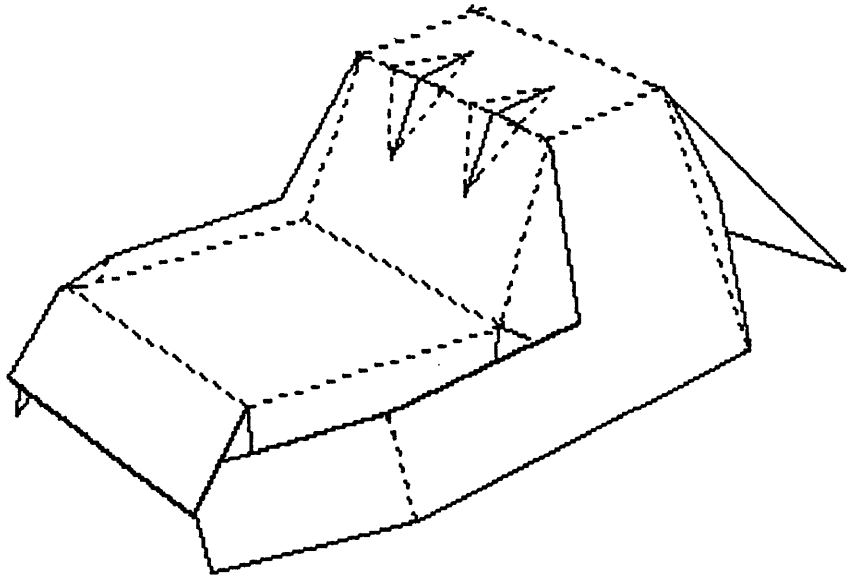


Glue the marked tabs after folding the pattern.

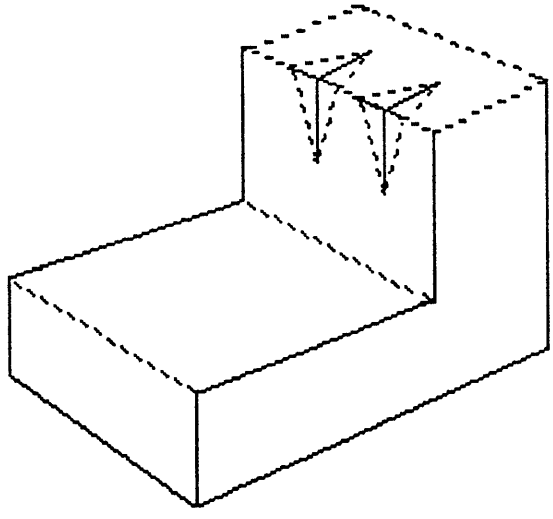
Glue

Make creases and fold along the dashed lines within the pattern, folding so the printed side faces outward.

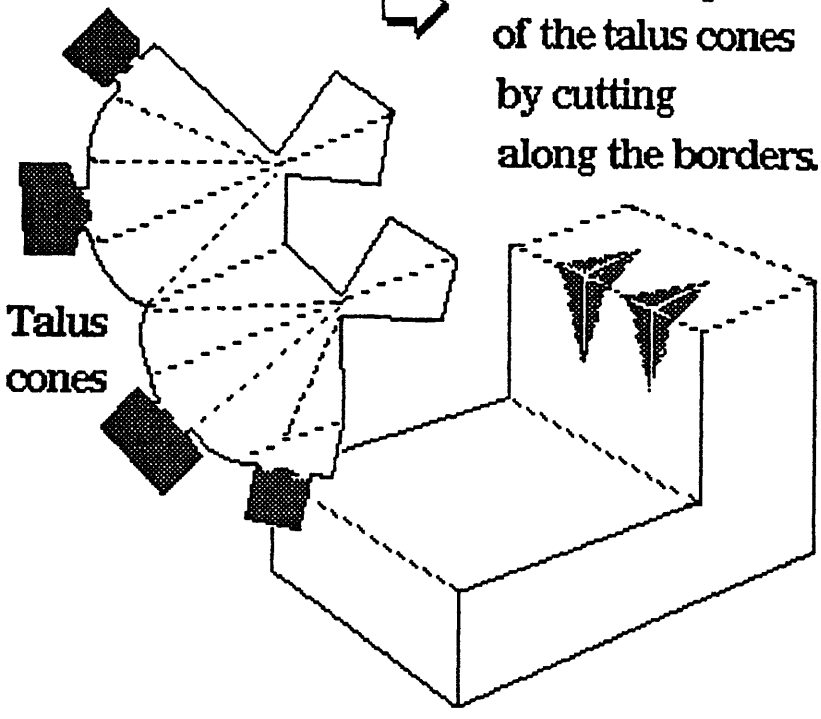




The assembled rockfall base should look like this.



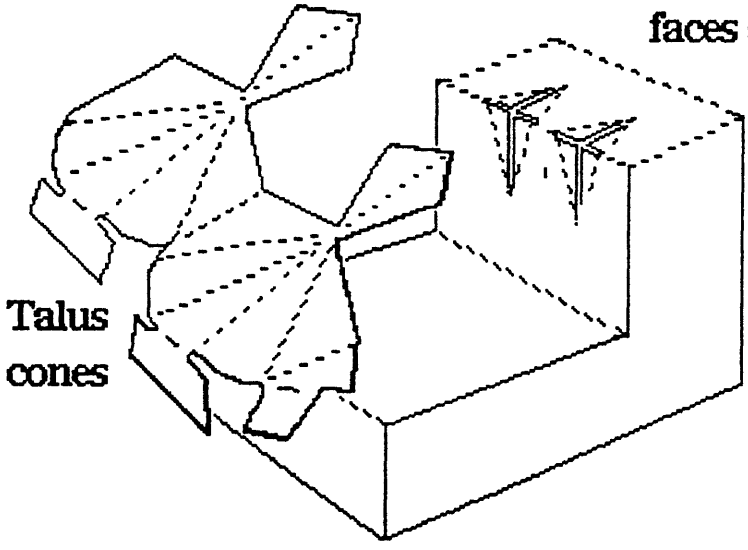
Cut out the pattern
of the talus cones
by cutting
along the borders.

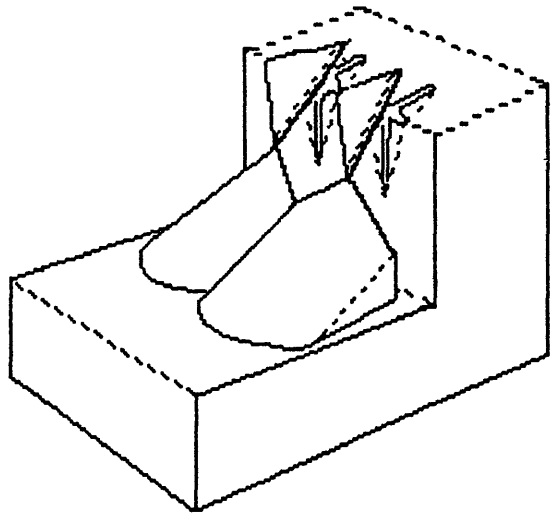


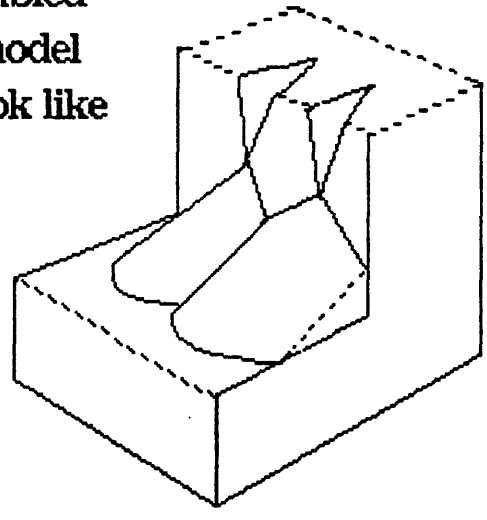
Glue

Glue the
marked tabs
after folding
the pattern.

Make creases and
fold along the dashed lines
within the pattern,
folding so the printed side
faces outward.



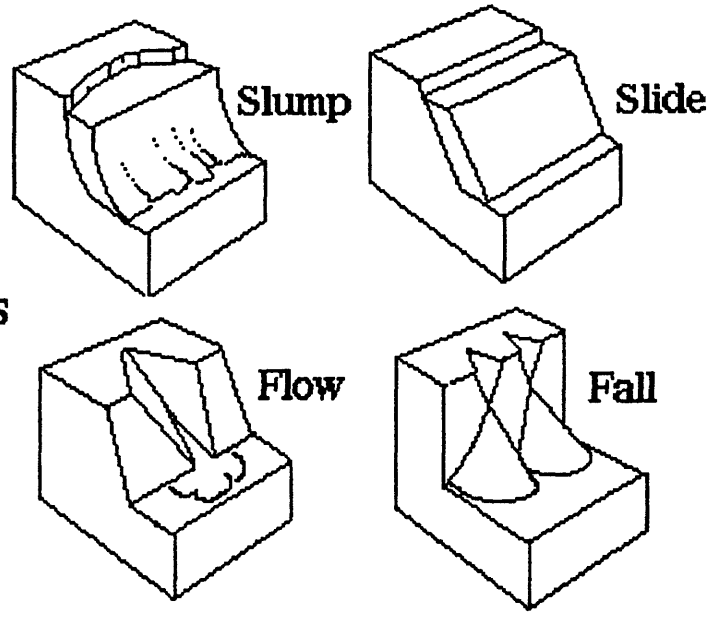


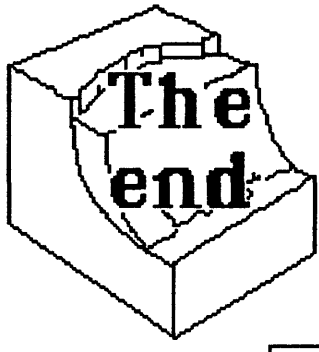


The assembled rockfall model should look like this.

Click on picture to see animations:

Animations of Landslide effects





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Landslide Effects

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