

PARK PRACTICE

Architectural Photogrammetry

Architectural Photogrammetry is fast becoming a widely used tool for preservationists. Combining the principles of photography and geometry, photogrammetry is a method by which scaled drawings can be obtained from photographs, shortcutting laborious hand measuring techniques. Simply stated, the process makes use of photographs taken from known locations to create an optical model that can be scaled or measured in all directions. It is particularly useful for studying large and complex structures or groups of buildings, as in historic districts, where hand measuring would be prohibitively expensive.

Stereophotogrammetry

There are several kinds of photogrammetry varying in technique, accuracy, and expense. The most accurate and widely used is Stereophotogrammetry. Two or more overlapping

photographs are taken at successive camera positions or stations, normally with the camera axes parallel. The locations of the camera stations are carefully measured in relation to the building, specifications of the camera are noted, and some points and dimensions are established on the building or in the space before it. These data are known as survey control.

Stereophotogrammetry may be either terrestrial or aerial. Terrestrial photogrammetry is used for showing individual buildings or groups of buildings in elevation. It is the best way to record small dimensions since the camera-to-subject distances are short.

Aerial photogrammetry is used for mapping and making plans for districts. Survey control in this case includes some targeting or knowledge of elevations, distances, and direction of points on the ground and the course, altitude, and speed of the plane as well as the time between successive expo-

tures.

The products of both processes are photographic stereopairs which, when placed in a plotting machine, present the illusion of a three-dimensional optical model. The same principle can be seen in a child's Viewmaster. Using the survey control, this model can be accurately measured and points can be plotted on paper at any desired scale. A draftsman then joins these points to produce a measured drawing in standard orthographic projection.

The number of stereopairs needed to document a structure depends on the nature of the building and its environment. Elevation drawings are best made from stereopairs taken perpendicular to the building, while oblique views are best for determining measurement of features in more than one plane such as cornices, roofs, and spires. Repetitious views taken from several distances and angles may, therefore, be required. Trees, adjacent structures, and other obsta-



cles that obscure the view may also increase the number of stereopairs needed.

Rectified Photography

The second and simplest technique of photogrammetry is known as rectified photography. It produces a straight-on view free from the usual photographic distortions. Because distortion is corrected, accurate measurements can be made directly from the photograph. The accuracy of rectified photography is limited to a single plane, and it is best used to document flat exterior or room elevations. It cannot, for example, accurately record the receding slope of a gable roof.

Rectified photographs are achieved in two ways. An ordinary photograph may be projected in an instrument called a rectifier, which corrects for any tilt, rotation, or obliquity of the camera to the subject. Or the position of the camera taking the photograph can be carefully manipulated so that the image plane of the camera is exactly parallel to the facade at its center point. A report, "Rectified Photography and Photo Drawings for Historic Preservation," is available from the Technical Preservation Services Division, USNPS.

Analytical Photogrammetry

Analytical photogrammetry, also called reverse perspective analysis, is the most expensive and time consuming, but because it uses ordinary contemporary or historical photographs, it is extremely useful for making drawings of damaged or demolished structures. It combines the use of one or more photographs for which the camera position can be determined with geometric

calculation of the major dimensions of the structure. Accuracy depends on the quantity and quality of photographs available. This technique has been particularly valuable for the restoration of war-damaged buildings in Europe.

Advantages of Photogrammetry

Photogrammetry has some distinct advantages over traditional documentary methods. Stereopairs and survey controls form a complete, inexpensive, easy-to-store record of a building. The preparation of drawings can be delayed until some later time, thus deferring one of the major costs of documentation. When drawings are prepared, however, the plotting and drafting require sophisticated machinery and photo interpretation technicians trained to recognize and delineate architectural features. The costs are usually more for photogrammetric drawings of a small building than for regular measured drawings.

Other advantages are that the work on the site can be completed in a short period of time, an important consideration with threatened structures. The accuracy of photogrammetry can detect irregularities and deformities in a building better than hand measurement. Photogrammetry also permits a record to be made of buildings that are too large, complex, or dangerous to be recorded by hand.

Background and Use

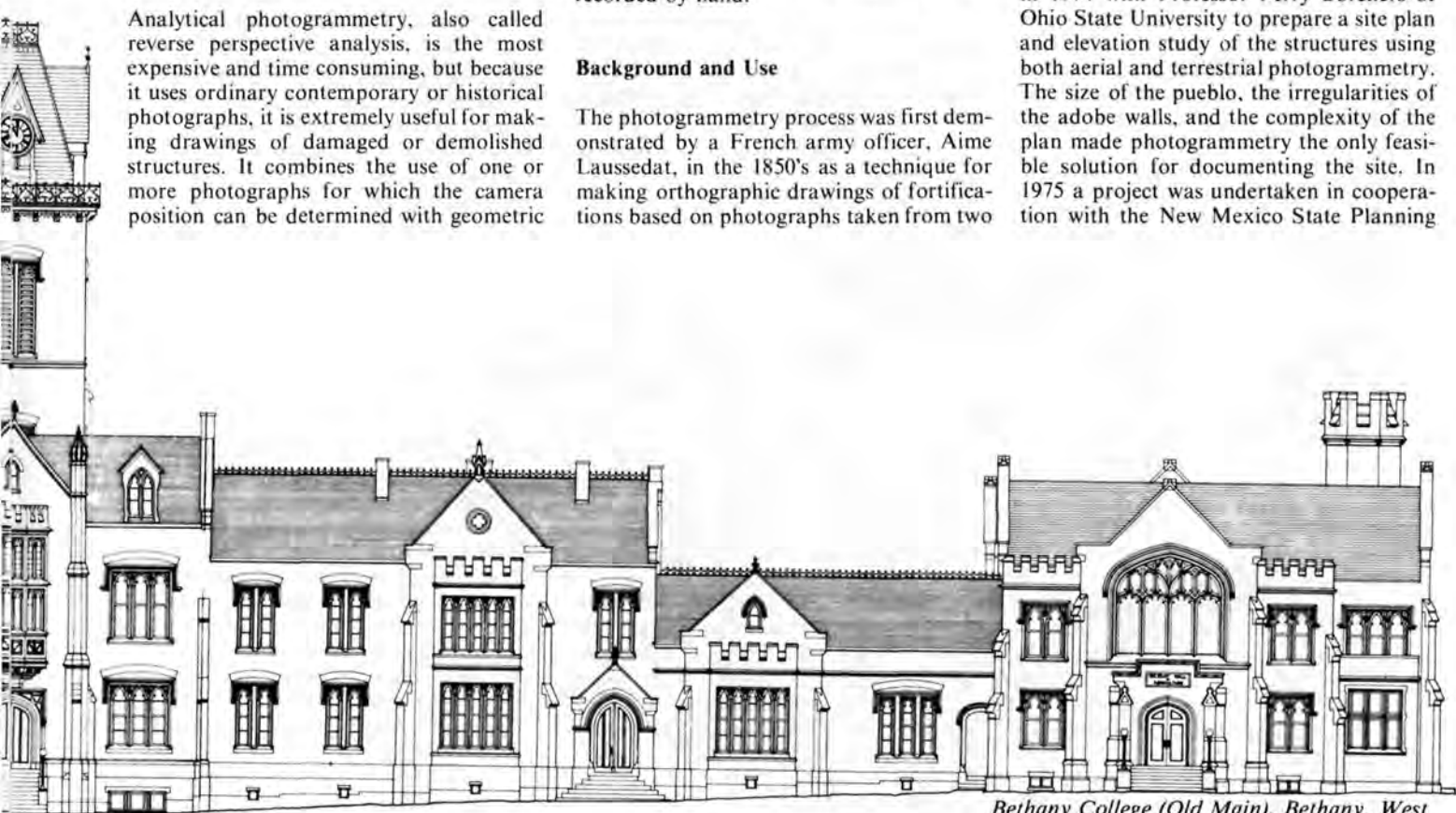
The photogrammetry process was first demonstrated by a French army officer, Aime Laussedat, in the 1850's as a technique for making orthographic drawings of fortifications based on photographs taken from two

different points. The limitations of early cameras and lenses hindered further development, and it was not until the late 1860's that Albrecht Meydenbauer, a German architect, was able to make accurate measured drawings of a church in Freiburg, Germany. In 1885 Meydenbauer organized the first systematic photogrammetric architectural survey, the *Messbildanstalt* in Berlin.

Edward Dolezal, an Austrian professor, developed stereophotogrammetry, the most commonly used technique for documenting historic structures, about 1900. Advances in technology have made increasingly precise and sophisticated cameras and plotting machines available in this century, but the basic techniques still derive from the work of Dolezal.

The destruction that accompanied World War II was the impetus for comprehensive documentation projects in many European countries. By 1956 the Belgians had recorded most of their architectural landmarks and the French Institut Geographique National had begun recording the Egyptian monuments in the Aswan Dam flood pool.

The Historic American Buildings Survey (HABS) has been experimenting with photogrammetry since 1957. Three recent projects illustrate its usefulness and versatility. To assist in the restoration of Acoma Pueblo in New Mexico, HABS contracted in 1974 with Professor Perry Borchers of Ohio State University to prepare a site plan and elevation study of the structures using both aerial and terrestrial photogrammetry. The size of the pueblo, the irregularities of the adobe walls, and the complexity of the plan made photogrammetry the only feasible solution for documenting the site. In 1975 a project was undertaken in cooperation with the New Mexico State Planning



Bethany College (Old Main), Bethany, West Virginia (southeast elevation). Drawing by Timothy Allanbrook, 1976, for HABS.



These two drawings (top and bottom of this page) of the Pueblo of Acoma in New Mexico, U.S.A., illustrate how both aerial and terrestrial photogrammetry can be used to document large and complex sites. Irregular structures such as a pueblo have few straight lines or repetitious structural elements. To measure such structures by hand would be prohibitively expensive and time consuming. The aerial stereopairs were taken nine years before the drawings were made. The major cost of plotting and delineating the drawings was deferred until the drawings were actually needed. These drawings, part of the first complete documentation of the pueblo, will be used in planning the preservation and restoration of the site.

Office to document the traditional plans and architecture of Spanish-American towns along the Pecos River. The necessary aerial and terrestrial stereopairs were made and plotted before the HABS team arrived on site to do the drafting. In 1976 a project cosponsored by Bethany College in West Virginia produced "as-is" drawings of Old Main prior to restoration work. Because of the size of the building, a combination of photogrammetry and hand measurements was used. The HABS team hand measured and drew the plans and drafted the elevations based on photogrammetric plottings

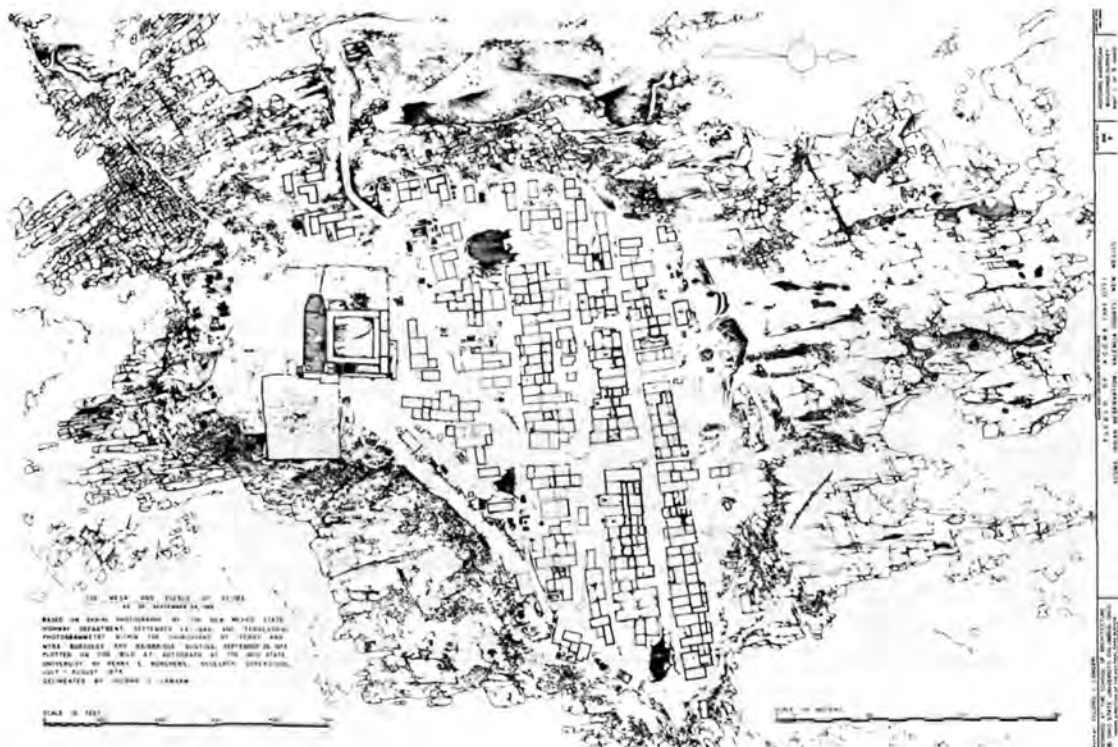
also by Professor Borchers.

These examples illustrate some of the ways in which HABS is using photogrammetry. The speed, accuracy, and adaptability of photogrammetry will undoubtedly lead to wider acceptance and use of this technique in documentation and restoration work throughout the country.

Information on the use of photogrammetry internationally is available from the International Committee on Architectural Photogrammetry, 2 Avenue Pasteur, F-94160 Saint Mandé, France. The American Society of Photogrammetry, 105 North

Virginia Avenue, Falls Church, VA 22046, publishes a monthly journal, *Photogrammetric Engineering and Remote Sensing*, and sells other publications on photogrammetry.

John Burns, the author of this article, is an architect with the Historic American Buildings Survey. The article was adapted from an information release published by the Office of Archeology and Historic Preservation, USNPS.





Snow Caves and Shelters

In national parks where heavy snows occur, substantial increases have been noted in winter activities. More and more people are finding that the rewards of visiting parks in winter are substantial: crowds of people are not present to scare away the wildlife; snow adds a new dimension of beauty to the surroundings and brings new opportunities in recreation. Furthermore, even bad weather—if it is not too severe—can be tolerated if you go prepared.

Those two words are emphasized in the information on winter travel given out at Rocky Mountain National Park (USA), and that is also the message we try to portray in a special snow cave exhibit in the visitor center at the park. *Go prepared!*

The idea for the snow cave exhibit resulted from a need to stress safety precautions to the crosscountry skiers and winter campers, and the hazards of traveling in the mountains in winter. All the essentials of a winter trip were shown in the exhibit. Skis, poles, and snowshoes stood in the artificial snow outside the cave. Inside were the essentials: snow shovel, stove, cooking kit, food, insulating pad, sleeping bag, warm clothing, extra socks and gloves, sunburn cream, sunglasses, and first aid kit.

Key features in snow cave construction were also shown, such as a vent or chimney for the stove, a ski pole through the ceiling to keep the ventilation hole open, an en-

trance below the living level to keep the warmth in, and sleeping shelves carved into the side. The stove, in its niche, rested on the blade of the snow shovel.

Rather than clutter up the exhibit with signs and labels, a few pertinent questions were listed on a panel beside the "cave," and an illustrated information sheet on snow shelters was available at the nearby information desk.

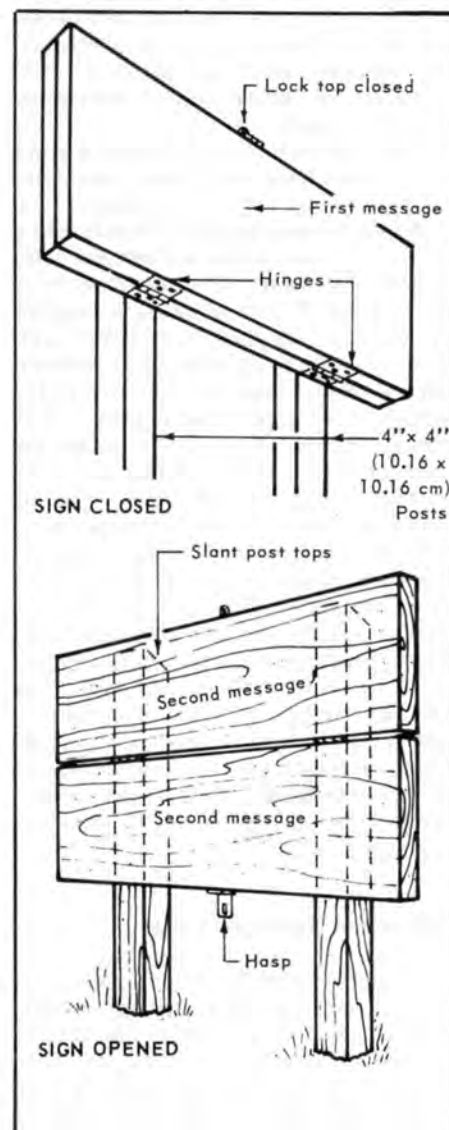
Materials used in construction were woven chicken wire to form the ceiling and walls of the "cave." Polyester fiberfill batting (for quilting) was used to simulate snow and was stitched loosely to the wire frame.

Winter overnight use in Rocky Mountain National Park has been increasing steadily. Many parties use tents, but caves and other types of snow shelters are used also. For several winters past, a seminar was given in late February or March, actually putting into practice the use of snow caves, trenches, and such (see photo).

Between January 1 and April 30, 1976, more than 550 permits for overnight backcountry use were issued to groups having an average of 2 to 3 people per party. With that many people involved, some accidents can be expected. But those who go prepared are not likely to get into trouble. It is the day skier or hiker who unexpectedly has to spend the night in the cold without preparation who is most in need of a snow shelter.

Two-headed sign

Where sign messages must change frequently, as on a trail or road that is opened or closed periodically, this simple convertible signboard should provide a ready answer. It consists of two display boards of equal size, fastened together with hinges. To change the sign message one simply removes the lock on top and lets the face panel down to uncover the second sign message. This idea comes from Ranger Jacob Hamilton, USNPS.



If he knows there is warmth (a consistent temperature of -3.8° to -1.1°C) beneath the snow, protection from the wind, which also contributes to warmth, and how to use the usually abundant snow as shelter material, he will survive unharmed. The Park was fortunate that there were no fatalities during the winter due to lost or trapped skiers. —Marjorie Dunmire, Rocky Mountain Nature Association

Safe Exterior Stairs

How many falls on stairs in national parks have been caused by poor design we will never know. We must be sure that any stairs built today or in the future are as safe as we can build them. There should be no compromise where safety of visitors and employees is concerned.

This discussion concerns exterior stairs only. Interior stairs are generally built (in the U.S.A., at least) to comply with one of several building codes that are concerned with public safety. Exterior stairs usually do not have a code to follow, but we do know how to design these stairs for greater safety. The following guidelines based on U.S. National Park Service criteria are presented with this in mind.

Stairs should not be used where a ramp can be substituted. Still, many conditions will warrant stairs as well as a ramp.

Before discussing criteria, let us look at a definition. In the words of Professor John Hancock Callendar of Pratt Institute, stairs are: "A stepped footway having a gradient not less than 5:16 pitch, or 31-1/4 percent, or an angle of 17 degrees and 21 minutes; and not greater than 9:8 pitch or 112-1/2 percent, or an angle of 48 degrees and 22 minutes. Below these limits, footways become ramps; above them stepladders."

Interior and exterior stairs may be further divided at 30 degrees slope angle: below 30° is exterior; above 30° is interior. The more gentle slopes are used for exterior stairs because walking pace is leisurely, space is usually available, and more dangerous conditions can exist with adverse weather such as rain, ice, and snow. The steepness, width, and detail of a stairway depend on where it is, who is to use it, traffic conditions, and the construction and maintenance budget. Each stairway would therefore be unique as all of these requirements vary.

Vertical and Horizontal Limits

The change in levels should never exceed 6 feet (1.83 m) without providing landings. (Figures 1 & 2) These landings should be at intervals of about 4 feet (1.22 m). They should be as wide as the stair and long enough for a man to take two or three normal steps, approximately 6 feet (but no less than 4 feet). Tread width will determine the horizontal run which is tied to the riser height. There should never be less than three treads or steps; one or two are a hazard. Treads must be plainly visible to help prevent stumbling.

Tread and Riser Relationship

There isn't much agreement among professionals as to the proper tread/riser relation-

ship. Generally, exterior treads are wider and risers are shorter. One formula has evolved from the length of an average person's stride: two risers plus one tread equals 26 inches (66 cm). Five and one-half inches (14 cm) is a good riser dimension to begin with. A 5½ inch riser would permit a tread 15 inches (38 cm) wide. In no case should the riser be less than 4 inches (10 cm) or more than 6½ inches (16.5 cm); the tread must never be less than 13 inches (33 cm). All treads and risers in a series must have uniform dimensions and be perpendicular to the direction of travel.

Tread and Riser Design

Tread nosing should be rounded or chafed, one inch rounding (about 25 mm) being the most acceptable. (Fig. 2) Treads must not overhang more than 1½ inches (38 mm). Nosing must be slip-proof, and should be of contrasting color to treads and risers to make visibility and identification easier. Treads should be slip-resistant. Risers must never be open except for a ½-inch (13 mm) shadow line or drainage slot at the tread. The top and bottom tread of each flight must set back at least 12 inches or 30 cm (several times that is best) from traffic per-

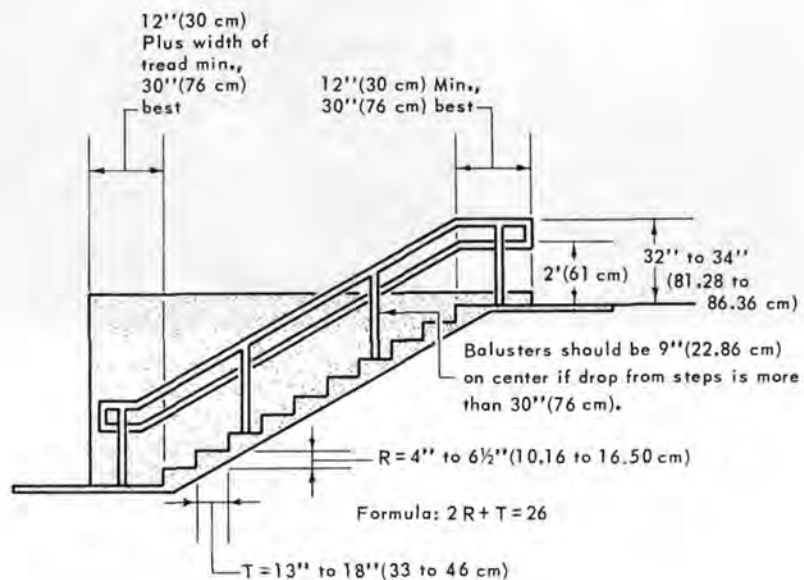
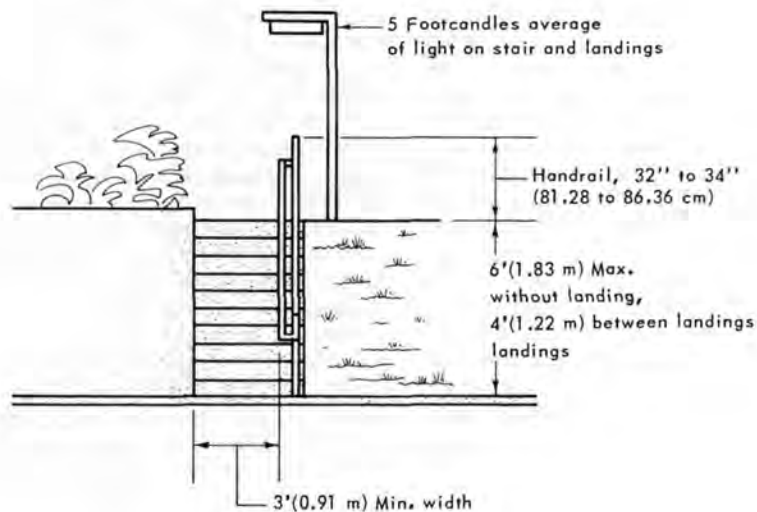


Fig. 1

SIDE VIEW



FRONT VIEW

pendicular to the stairway. (Fig. 1) Tread finish should be different from walks for a warning. Tread finish should be carried about 4 feet (1.22 m) beyond the stairway at the top and the bottom to warn traffic in the same direction of the stair.

Stair width

The minimum clear width should be 3 feet (91 cm). Width should be increased to handle traffic where steps have heavy use.

Handrails

Handrails should be $1\frac{1}{4}$ to $1\frac{1}{2}$ inches (3-4 cm) in diameter and should be mounted at least two inches (5 cm) clear of any wall (Fig. 3) with ends returned to walls. They must be located at least 32 inches (81 cm) above the leading edge of the treads (they may be as high as 34 inches—86 cm). (Fig. 1) Handrails must extend 12 inches (30 cm) beyond the top riser and 12 inches plus the width of one tread beyond the bottom riser. These extensions must be parallel to the floor and must not project into the walkway spaces. Handrails must be continuous on one side of a stair, including landings. Continuous on both sides is preferred, and essential, of course, if stairs are open on both sides. The gripping surface of the handrails must be continuous and unbroken. Anytime children are expected to use the stair, a second handrail at 24 inches high (61 cm) should be provided. When steps are very wide, as across the front of a building, for instance, handrails should be

provided 20 to 30 feet (6 to 9 m) apart. Handrails must be able to support 250 pounds (113.4 kg) in any direction.

Lighting

Regularly used stairs should have a minimum average of five footcandles of light distributed to create shadow to show beginning and end of the stair, and the edge of each tread. The light source should be above the stair and set to one side. (Fig. 1) This position will provide a more accurate definition of each tread. Flush mounted indirect fixtures in side walls and risers usually prove to be more costly to install and maintain and do not light stairways as well as the overhead type.

General Notes

Stairs must be designed to prevent accumulation of leaves, litter, water, ice, snow, and other matter that could affect safe use. The safest stair can become a death trap if debris collects on a step or ice or snow isn't removed. Every stair should be regularly cleaned and maintained.

Attention to these details should assure the construction and maintenance of a safe stair.

Guardrails

Guardrails are another means of protecting the visitor that must follow some basic safety criteria. By one definition, guardrails, or guards, are "a vertical protective barrier erected along exposed edges of stairways, balconies, etc." A handrail is "a bar, pipe, or similar member designed to furnish people with a handhold. (A handrail, if of suitable design, may also serve as part of a guard.)"

Guardrail locations are subject to controversy. At what minimum grade difference or elevation change are guardrails required? Logic dictates a guardrail anytime a hazard exists, such as any abrupt change in grade. That would be impractical as most curbs would then have guardrails. More appropriate would be to provide a guardrail if there is to be a difference in grade of 30 inches (76 cm). Any condition less than that should require careful consideration of traffic, location and people using the area.

If a guardrail is to be installed, the following details should be considered for safety: Rail height must be a minimum of 42 inches or 1.06 m. If the guard faces a grade change or dropoff more than 25 feet (7.6 m), the rail should be increased to 48 inches (1.22 m) for the benefit of persons having a fear of high places.

Guardrails must be able to support high loads. This is figured at a minimum of

250 pounds or 113.4 kg in any direction, 50 pounds (22.68 kg) per lineal foot (applied horizontally 42 inches or 1.06 m above grade) whichever condition would produce the maximum stress.

The area between the guardrail and floor must be filled in by one of the following:

- Intermediate longitudinal rails spaced so that the clear distance between them does not exceed ten inches (25 cm). This would include space between the bottom rail and grade or floor.

- Posts (or balusters) spaced with a maximum clear distance of six inches (15 cm) between them.

- Any panel of timber, plywood, solid wire mesh, expanded metal, or any ornamental grille that would provide equivalent protection against falling as the rails or posts mentioned above.

- Masonry wall may be used for any portion.

- Any combination of the foregoing that would provide equivalent safety.

Any opening in the guardrail must be designed to prevent loose clothing or jewelry from becoming caught or wedged in such openings. A continuous six inch (15 cm) high curb under the guardrail will help prevent small objects from rolling or falling through.

Larry N. Kilborn, author of this article, is an architect with the Denver Service Center, USNPS.

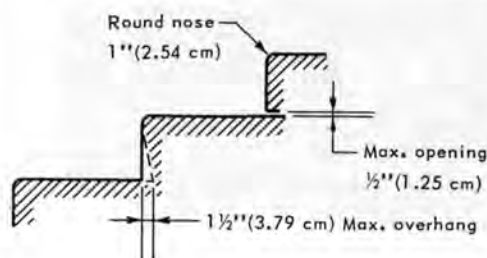


Fig. 2 DETAIL OF STEPS

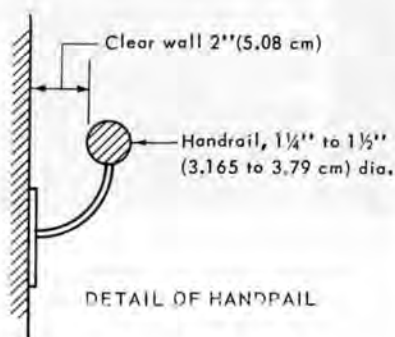


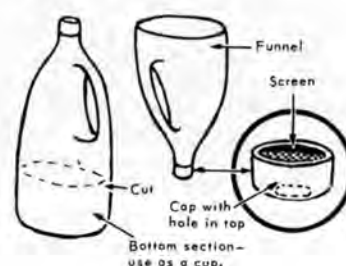
Fig. 3

Simple money-saving ideas

Save paint



Make a funnel from a discarded plastic jug



Proteus, a mini mobile unit for conservation education

As part of a special program to promote conservation education in areas where schools and other facilities are few or far between, the World Wildlife Fund has initiated the design, and financed the development of a new "mini" mobile education unit. The unit is well-adapted for use in national parks, and the first one, in fact, is destined for field use in Senegal, West Africa.

Escalating vehicle and oil prices have placed the relatively well-known, robust four-wheel drive "filmmobile" outside the budget available in many countries. WWF therefore adopted the Renault 'Fourgon' van as its basic vehicle in an attempt to prepare a versatile and economical mobile unit with a price tag below US \$6000. Although the photographs showing the conversion apply to this particular van, there is no doubt that with a little imagination and ingenuity, almost any van, truck, or estate car could be adapted for the same purposes.

The Proteus unit has been designed to perform four major functions:

(1) It operates as a public address system, the roof mounted speaker being fed by a 15 watt amplifier contained in the slide/tape unit. In the first vehicle it is necessary to use the mobile generator to power the PA system, but the second unit will have a public address system which operates directly from the car electrical system. Used in this mode, operators of the unit may talk directly to groups of people, broadcast pre-recorded cassettes, or canvass audiences for film shows.

(2) A 6x4 foot (1.83 m x 1.22 m) roof mounted screen is quite large enough to show pictures adequate for audiences of several hundred people. Power from the compact Honda 300 EM generator is sufficient for either the ELF 16mm (magnetic or optical sound) projection equipment, or to operate Pandamatic slide/tape equipment. The Pandamatic unit has both recording and playback facilities, thus allowing the preparation of 'tailor-made' programs for local audiences in the field. The Kodak Carousel SAV 2000 projector with a long focus lens provides bright pictures even under conditions which are not ideal for projection. Both projectors are housed in rigidised aluminum cases which are rust proof and are strapped during transit into frames rivetted onto the floor of the van.

(3) The unit serves as a mobile exhibition center. Two large display frames are carried in the high dome at the rear of the vehicle and can be assembled using the same tubular aluminum poles which support the screen. Each frame is grooved to receive a display panel, which is reversible. The black formica surface is usually selected for displaying posters, wall-charts, photographs, etc., while the white side may double as a



rigid screen in conditions which are too windy to erect the canvas one. An extra partition in the roof stowage area is provided for large charts or prepared display material.

(4) An experimental rear projection screen has been hinged to the "false" roof inside and swings down after releasing two drawer bolts. By mounting the Pandamatic unit and Carousel Projector on the large aluminum storage case in the space formed by folding the passenger seat forward, an image can be reflected from a special mirror to the rear screen. The position of this screen is designed to allow for a bright picture in average daylight conditions.

Every effort has been made to provide



for these four functions as simply as possible. To avoid rusting in humid conditions, construction has used aluminum or galvanized parts throughout. Clearly the final test of such a prototype unit is its reliability in the field, and above all its effectiveness in bringing the importance of conserving natural resources to a wider audience.

Will these adaptations enable it to perform this task? Six months of operation throughout Senegal will doubtless provide the answer!

More information may be obtained from the Conservation Education Department, World Wildlife Fund, 1110 Morges, Switzerland. —Mark N. Boulton.

Minimum words, Maximum effect



Lying astride the delta of the Rhine river and within a few hundred kilometers of 6 other nations, The Netherlands has always had to cope with complex language problems. As one result, the Dutch have pioneered the use of signs having a minimum of words and maximum effectiveness. Here are several examples, including an excellent trail-side interpretive sign which presents basic facts on the Scots pine. The bottom piece of the metal frame is held in place with blind rivets. All are from the Staatsbosbeheer (State Forest Service), sent by Ir. W.G. van der Kloet.