NATIONAL BUREAU OF STANDARDS REPORT

3660

SELECTION AND MAINTENANCE OF FLOORS
FOR NAVAL SHORE ESTABLISHMENTS

By

Percy A. Sigler

Report to
Research and Development Division
Bureau of Yards and Docks
Department of the Navy

U. S. DEPARTMENT OF COMMERCE
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Floor, Roof and Wall Coverings Section
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ABSTRACT

Flooring problems relating to Naval Shore Establishments are discussed with emphasis on an over-all economical selection of flooring materials to meet existing performance requirements and proper maintenance procedures to protect and prolong the service life of the floors. Accident prevention, involving the slip-resistant characteristics of floor surfaces and electrically conductive floors for operating suites, is given consideration. The service requirements of floors as affected by the type of occupancy are discussed and appropriate recommendations made.

1. INTRODUCTION

1.1 Background

Floor maintenance materials and procedures have undergone considerable changes in the past several years. Much emphasis has been placed on research and the development of new materials for both cleansing and protecting floor surfaces as well as enhansing their appearance. The ease and cost of maintenance has been given due consideration by both the flooring and maintenance materials industries. An evaluation of present-day materials and recommendations for their safe and economical use are needed.

Accordingly, the Bureau of Yards and Docks, Department of the Navy, requested the Building Technology Division, National Bureau of Standards, Department of Commerce, to make a study of their floor maintenance problems and submit appropriate recommendations.

1.2 Purpose and Scope

The information and recommendations in this report are intended for the preparation of a floor maintenance manual which will serve as a guide to Public Works Officers and other personnel charged with the selection and care of floors in Naval Shore Establishments. The factor of safety or accident prevention is of paramount importance in some locations and has been taken into account in many of the recommendations.

2. GENERALIZED COMMENTS ON THE SELECTION AND CARE OF FLOORS

2.1 Selection of Floor

When selecting a flooring material for a particular location and type of occupancy, consideration should be given to the overall economical performance of the floor. This includes subfloor preparation, method of installation, and subsequent repair and maintenance requirements. Proper installation and adequate maintenance will result in curtailing the need for major repairs of practically all types of floors and will prolong and enhance their service life. The long-range net result may well be an economical and satisfactory performance of the floor covering.

Federal Specifications are available for such floor coverings as flexible and semi-flexible vinyl plastic tiles, several types of linoleum, rubber floorings, asphalt tiles, cork tiles, ceramic tiles, and hardwood block flooring. In addition to Federal, there are Departmental, Trade Association and Commercial specifications and standards for many flooring materials. These specifications and standards can be used as a

basis for securing good quality merchandise in their respective fields. However, they deal principally with the quality of a particular type of flooring material and not with the relative merits or outstanding properties of the various types. Comparable information on different types is of direct and economic interest to architects, structural engineers and procurement agencies in selecting a flooring material to meet a particular need.

In this report, space does not permit a detailed discussion of all of the characteristics of different flooring materials. A summary of the results of wear and indentation tests reported in National Bureau of Standards Building Materials and Structures Reports 34, 43, 68, 80 and 73 is given in Table 1. Comparable data on the more recently developed vinyl plastic tiles (Interim Federal Specification L-T-751, GSA-FSS) are not given in the table as this type of floor covering was not commercially available at the time of the tests. Other investigations indicate that vinyl plastic tiles have relatively good resistance to wear and reasonably satisfactory indentation characteristics. They are outstanding in resistance to grease, oils, alkalies and many other reagents. Vinyl plastic tiles are relatively high in initial cost, but their maintenance requirements are relatively low. Contrary to some manufacturer's claims, however, they are scratched and smudged sufficiently by foot traffic to warrant an occasional scrubbing and waxing in order to keep their appearance satisfactory.

TABLE 1. RELATIVE RESISTANCE OF FLOORING MATERIALS TO WEAR AND INDENTATION

FLOORING MATERIAL	NOMINAL THICKNESS, Inch	DEPTH OF WEAR,[a] Inch	RESIDUAL INDENTATION,[b] Inch
Maple unit block	25/32	.003	----
Strip maple, flat-grained	25/32	.002	----
Short-strip maple	25/32	.007	.001
Pecan unit block	25/32	.006	----
White oak unit block	15/32	.005	.002
Red oak unit block	15/32	.007	.003
Strip white oak, flat-grained	25/32	.010	.003
Strip yellow pine, flat-grained	25/32	.010	.005
Strip Douglas fir, edge-grained	25/32	.033	.005
Pressed fiberboard	1/8	.018	.000
Concrete, 1:2:4 mix	4	.025	----
Cement mortar, 1:2 mix	1	.010	.000
Magnesium oxychloride, granite chips and dust	1/2	.006	----
Magnesium oxychloride, granite dust	1/2	.012	----
Magnesium oxychloride, calcite dust and sand	3/4	.016	.000
Magnesium oxychloride, marble dust and cotton fiber	1/4	.018	----
Alumina cement-rubber latex, marble chips	1/2	.021	----
Alumina cement-rubber latex, ground cork and silica	1/2	.026	.017
Alumina cement-rubber latex, marble chips and volcanic ash	1/4	.055	.012
Asphalt mastic, volcanic ash	1/2	.039	----
Cork tile	5/16	.018	.044
Vinyl plastic tile, flexible	1/8	----	----
Vinyl-asbestos tile, semi-flexible	1/8	----	----
Rubber	1/8	.005	.003
Linoleum, burlap-backed	1/8	.004	.008
Linoleum, felt-backed	5/64	.005	.012
Asphalt tile	3/16	.017	.027[c]
Asphalt tile	1/8	.016	.018[c]
Pitch mastic, felt-backed	5/64	.017[d]	.022[c]

[a] Measurements are the depth of wear caused by 24,000 passages of a large, 275-lb. wheel which was shod with wooden blocks covered with abrasive cloth (BMS Reports 34, 43, 68 and 80).

[b] Measurements are the depth of indentation 7 days after exposure for 7 days, at a temperature of 72°F, to a load of 150 lb. on 3 dome-shaped metal glides of 1/2-in. diameter (BMS Report 73).

(Footnotes continued on next page.)

FOOTNOTES - TABLE 1. (CONTINUED)

[c] Residual indentations are much greater at a temperature of 90°F (BMS Report 73).

[d] Pitch-mastic surface was worn through in spots by 7,800 passages of the abrasive-covered wheel (BMS Report 43).

The cost of a particular type of flooring material may vary considerably depending upon differences in construction and composition. In addition, the cost of installing a floor covering is quite variable and depends to a large extent on subfloor preparation requirements, nature of the exposure or occupancy and the amount of cutting and fitting involved. The geographic location of the installation is also a factor affecting the total cost. An attempt has been made in Table 1 to list the flooring materials of a general type in the order of decreasing cost. The general types are: wood floorings, magnesium oxychloride compositions, cement-latex compositions, and so-called resilient floor coverings such as cork, vinyl, rubber, linoleum and asphalt tiles. In view of the many variable factors involved, the relative costs of floors of a different general type were not considered in the listing of the flooring materials.

2.2 Precautions

Probably the most damaging treatment of floors is an excessive exposure to water. Practically all floors are harmed by such treatment, particularly wood floors. Continued wetting of wood floors causes the grain of the wood to raise, the strips to expand and buckle, and eventually results in a splintered and split flooring with open seams and end joints.

Resilient-type floor coverings are doubly harmed by excessive exposure to water. Even though the floor covering itself may be fairly resistant to water, failure in bond to an underlayment or to the subfloor is most likely to result. With a wood subfloor, additional damage to the floor covering occurs due to the expansion and buckling of the flooring, or if a plywood underlay is involved, to the delamination of the plywood.

When wood and resilient-type floors need to be mopped in order to cleanse the floor surface, the least amount of water necessary to do the job should be used. Excess water should be wrung from the mop into a pail and not slopped onto the floor surface. When detergent solutions are used, the floors should be rinsed with clean water. (See Department of the Navy Technical Publication NAVDOCKS TP-PW-30, "Maintenance and Operation" and Department of the Army Technical Manual TM5-609, "Custodial Services".)

Repeated exposure to strong alkaline solutions or caustic preparations is harmful to most floors and will result in their early deterioration. The service life of linoleum, in particular, is materially reduced by the frequent use of alkaline cleaning solutions.

During a recent survey of floors in military structures in the various Army Areas,[1] it was noted that training courses on the care and maintenance of floors were instituted in a few Army Areas. It was also observed that, in general, the floors in these Army Areas were in relatively good condition. Such training courses are well worth while. They should, however, be carried on as a continuous program, due to the frequent changes in personnel assigned to custodial services at a particular Naval establishment.

2.3 Protective Coatings

Wax compositions are widely used as protective coatings for floors. Three general types have been commercially available for some time, namely, paste, solvent, and water-emulsion.

Paste and liquid, solvent-type or spirit waxes generally consist of a mixture of natural waxes and/or synthetic waxes in organic solvents, such as mineral spirits and turpentine. Paste waxes contain a relatively small amount of solvent. Some of the more commonly used

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[1] "Evaluation of Flooring Materials in Army Installations", by T. H. Boone, P.A. Sigler, and H. R. Snoke, National Bureau of Standards Report 2485, May 11, 1953. (A confidential report to the Repairs and Utilities Division, Office of the Chief of Engineers, Department of the Army.)

natural waxes are carnauba, ouricuri, candelilla, ceresin, ozokerite, paraffin, and beeswax. Carnauba wax is a desirable ingredient in a wax formulation as it has a high melting point and good resistance to scuffing and wear. However, it is too brittle to be used alone and must be blended with softer waxes. Practical information on the merits of the more recently developed waxes, such as microcrystalline and synthetic waxes, is not readily available.

Water-emulsion waxes, frequently labeled "self-polishing", "no-buff" or "dry-bright", are being more and more widely used as a protective coating for all types of floor coverings. Water-emulsion waxes usually consist of a mixture of carnauba wax and other natural or synthetic waxes dispersed in a water solution of soap or other emulsifying agents. These waxes are available in concentrations of 12 and 16 percent total solids or non-volatile matter (Interim Federal Specification P-W-00151b, GSA-FSS). Small amounts of natural resins, such as shellac and manila gum, and certain synthetic resins are sometimes incorporated in the emulsions to make them less slippery and improve other desirable characteristics, such as spreading and gloss. The addition of colloidal silica to water-emulsion waxes also improves their slip resistance. The colloidal silica should be added by experienced persons or waxes purchased which have such an additive. Based on total solids, the emulsion should contain approximately 30% silicon oxide.

Shellac-emulsion floor finishes containing little or no wax are currently available. In general, they have very good slip resistance. However, some have been found to have poor resistance to scuffing and water spotting and are difficult to remove from floor coverings. Some cause light-colored surfaces to become yellow.

Floor waxes and sealers are basically electric insulators. Investigations[2,3] indicate that improper selection and application of so-called conductive sealers and waxes may increase the electrical resistance of a floor surface sufficiently to create an explosive hazard from electrostatic sparks in locations where highly combustible materials are used, such as in hospital operating rooms and munitions plants. If a conductive coating is used it should be completely stripped or removed from the floor before renewing as repeated applications may build up an insulating film.

2/ "Conductive Waxes" by W. W. Walton, E. G. Borchardt, F. L. Hermach, and Miss R. C. McAuliff, National Bureau of Standards Report 2046, November 10, 1952. (A confidential report to the Bureau of Ordnance, Department of the Navy.)

3/ "Sealers for Conductive Terrazzo Floors in Hospitals", by N. L. Griffin, The Construction Specifier, Vol. 5, No. 3, January 1954.

Paste and water-emulsion waxes are suitable as a protective coating for sealed wood floorings and vinyl plastic, rubber and linoleum floor coverings. Liquid, solvent-type waxes are intended primarily for sealed wood floorings. They can be applied more easily in uniform thin coats than paste wax. The solvents are volatile and highly flammable, so that suitable precautions should be exercised in storing and handling floor wax of this type. Solvent-type waxes should never be used on asphalt tiles as the turpentine or mineral spirits in such waxes will soften or dissolve the tiles, causing the colors to bleed. Use only water-emulsion waxes on flooring materials containing asphalt, bitumen, or pitch. When in doubt as to which type of wax to use, a water-emulsion wax should be used as wax of this type will not harm any flooring material in common use today.

In general, paste and liquid, solvent-type waxes are more durable than water-emulsion waxes and may be desirable as an initial protective coating where applicable. Buffing is essential for paste and solvent-type waxes in order to obtain a satisfactory and glossy finish. Water-emulsion waxes are recommended for subsequent maintenance as they are non-flammable, less slippery than solvent-type waxes, and can be readily applied in very thin coats, thus retarding wax build-up from repeated applications. In order to avoid wax build-up along walls, do not apply wax within 6 to 8 inches of the walls when rewaxing. While buffing of water-emulsion waxes is not essential, it will improve

the distribution, gloss, and slip resistance of the wax coating. Water-emulsion waxes should be wiped on gently, not rubbed on. Two thin coats, with ample drying time between coats, are much better than one thick coat. Most wax emulsions require at least 30 minutes between coats for drying; on humid days, a longer period may be required. Traffic should not be permitted on freshly waxed floors until the wax emulsion is sufficiently dry (6-8 hours) and the area should be so designated by appropriate signs. Complete drying of the wax coating may require from 24 to 48 hours, depending upon atmospheric conditions. During this period the waxed floors are at their most slippery stage. Buffing will accelerate the drying of the wax film. If at all feasible, floors should be cleaned and waxed after normal working hours when traffic is at a minimum.

The systematic polishing of waxed floors with No. 000 steel wool will prevent heavy wax build-up and remove soil. Such a procedure will lessen the need for washing the floors. Worn areas should be rewaxed and buffed.

3. RECOMMENDATIONS FOR FLOORS IN NAVAL SHORE ESTABLISHMENTS

3.1 Administration, Instruction, and Recreation Buildings

Floors in these buildings are subject to appreciable foot traffic and severe indenting loads from furniture. Small-sized casters and metal domes on all movable furniture and equipment should be replaced

with ample-sized casters or flat gliders, especially where resilient-type floor coverings are involved. Heavy equipment should be placed on protective blocks or cups.

Concrete floors, on- or below-grade, in need of repair, should be leveled with a troweled-on underlayment and covered with 1/8-in. asphalt tile or semi-flexible vinyl plastic tile using a cut-back type asphalt adhesive.

Suspended concrete floors, those not in direct contact with the ground, and strip-wood floors in unsatisfactory condition should be covered with an underlayment and a resilient-type floor covering. Rough concrete surfaces should be made even with a troweled-on, latex-type underlayment. All springy boards and loose ends in a strip-wood subfloor should be securely nailed. While a sanding and felt underlay may be satisfactory in some cases, the use of a hardboard underlayment, not less than 3/16 in. thick, is recommended. The hardboard should be nailed on 6-in. centers in each direction over the entire area with ringed or barbed nails at least 1-3/4 in. long.

In view of the likelihood of localized areas being damaged by severe indenting loads and the rearrangement of equipment and space, the use of resilient-type floor coverings in tile form is particularly

recommended for administration, instruction and recreation buildings, to accommodate economical and satisfactory replacements at damaged areas.

The following floor coverings in 1/8 in. thickness are suggested: Flexible and semi-flexible vinyl tiles, rubber tile, and linoleum tile. They are durable floor coverings, easy to keep clean and require only a moderate amount of waxing as a protective surface coating. Felt-backed vinyl tile and felt-backed linoleum tile with a wearing surface of about 0.03 in. thickness and 1/8-in. asphalt tile are lower in initial cost than the above floor coverings and may render satisfactory and economical service in some locations. Their indentation characteristics are not as good, particularly at elevated temperatures. Asphalt tile indents readily at temperatures above 100°F, which is quite possible from direct rays of the sun (See N.B.S. Building Materials and Structures Report 73, "Indentation Characteristics of Floor Coverings"). Asphalt tile, however, is one of the few floor coverings which can be installed satisfactorily over concrete floors in direct contact with the ground without the concrete slab being thoroughly waterproofed.

3.2 Quarters

(A). Barracks Type

Insofar as could be ascertained by a limited survey of Naval Shore Establishments, both concrete and strip-wood floors are prevalent in barracks-type quarters. Many of the wood floors consist of oak flooring.

Whether the existing floor should be refinished or covered with another flooring material depends largely on the condition of the existing floor and the floor characteristics desired.

The dusting and staining of concrete floors can be retarded by the use of surface hardeners such as magnesium fluosilicate, sodium silicate, aluminum sulphate, and zinc sulphate. The painting of concrete floors is not recommended as the paint soon wears through in traffic lanes and the repainting of worn areas will show lap marks. Waxed concrete floors are likely to be very slippery.

Where concrete floors are to be covered, the recommendations as given in 3.1 for resilient-type floor coverings are also applicable for barracks. Other flooring materials which should render satisfactory service are integral-hardened concrete toppings, magnesium oxychloride cement as specified by the American Standards Association Specification ASA-A88.3-1952, "Heavy Duty Oxychloride Composition Flooring and Its Installation", and synthetic resin latex-alumina cement composition flooring. It is essential that the existing concrete floor be thoroughly scarified and cleaned before installing these monolithic-type flooring materials in order to secure an adequate bond between the two floorings.

Hardwood floors in reasonably good condition should be refinished where needed. The most practical procedure is to machine sand the floor and finish with a varnish-type floor sealer (Federal Specification TT-S-176a). Floors which have been previously treated with non-drying oils should be thoroughly scrubbed with a mixture of synthetic detergent and trisodium phosphate, using only enough water to float the oil to the surface. After removal of the oil, the floor should be rinsed and thoroughly dried before machine sanding. Such a floor should be finished with a lacquer-type floor sealer (Federal Specification TT-S-171) in order to seal in any residual oil in the wood. All open-grained wood, such as oak and pecan, should be filled with a paste wood filler (Federal Specification TT-F-336) before sealing and waxing. Machine-polished paste or solvent-type waxes (Federal Specification P-W-158) are recommended as an initial protective coating for all wood floors. Water-emulsion wax (Interim Federal Specification P-W-00151b, GSA-FSS) is recommended for subsequent maintenance.

Where it is more practicable to cover existing wood floors, the recommendations as given in 3.1 for resilient-type floors over a hardboard underlayment are applicable for barracks. Provision should be made for protecting such floor coverings against severe indenting loads (See Fig. 1).

Monolithic-type flooring materials which should give satisfactory service, if properly installed, are magnesium oxychloride cement (ASA Specification A88.3-1952) and synthetic resin latex-alumina cement composition flooring. Over a wood subfloor the following method of installation is recommended:

All springy boards and loose ends should be securely nailed. A layer of 15-lb asphalt-saturated felt (Federal Specification HH-F-191a) should be laid over the wood floor with edges and joints of the felt lapped not less than two inches and tacked in a manner sufficient to hold the felt in place until metal mesh is placed. Right-angled dividing strips of brass or suitable plastic, not less than 1/16 in. thick, and of sufficient width to conform to the thickness of the flooring, should be nailed to the felt and wood flooring. The dividing strips should be placed at not more than 30-ft. intervals and at inside entrances to hallways and rooms. Over the felt and butted tight to the dividing strips, an anchoring medium consisting of 2.5 lb./yd^2, small, diamond-mesh, painted, expanded metal lath, conforming to Federal Specification QQ-B-1016, should be laid with joints lapped at least 1/2 in. The lath should be nailed with 1-1/2 in., large head, galvanized, roofing

nails, except over joists, where nails should be of sufficient length to extend not less than 1-1/2 in. into the floor joists. Lath should be nailed on 6-in. centers in two directions and driven tight enough to secure the lath to the wood floor, but not hard enough to force the lath into or puncture the felt.

Magnesium oxychloride cement should be worked into the lath and finished by experienced workmen. The time and manner in which the final troweling is done is quite important. If a smooth, dense surface is not obtained, the floor should be ground with steel wool and sealed with a penetrating sealer of low viscosity, 1.1 to 1.5 CPS at 70°F as determined by a standard Stormer Viscosimeter. Varnish-type sealers intended for wood floors are not satisfactory for oxychloride floors. Floors having a porous surface should be resealed at least every six months. An occasional waxing with a thin coat of water-emulsion wax, pigmented if desired, will materially improve the appearance of the floor. The thin wax coating should be buffed to reduce its slipperiness.

(B). Family Type

Where hardwood floors are in good condition, the procedures for refinishing and maintaining such floors in barracks (3.2-A) should be followed. Where it is desirable to cover existing floors, the

installation of resilient-type floor as outlined in 3.1 is recommended. In view of the outstanding resistance of vinyl plastic tiles to grease, oils, alkalis, and many other reagents, such floor coverings are particularly suitable for kitchens and bathrooms. Contrary to some manufacturer's claims, vinyl plastic floor coverings do scratch and smudge sufficiently to warrant an occasional scrubbing and waxing in order to keep their appearance satisfactory. It should be remembered that practically all smooth-surfaced floors are slippery when wet, and especially so when waxed.

3.3 Mess Halls

(A). Dining Areas

Floors in these areas are exposed to considerable abuse. They are subject to severe indenting loads and scratching from chair and table legs having rounded and small-sized domes rather than ample-sized (3/4 - 1 in. diam.) and flat-surfaced glides. They are exposed to frequent food and water spillage and to heavy foot traffic, especially in food dispensing areas and along serving lanes. Also the floors require frequent washing to maintain them in a clean and sanitary condition.

Vinyl plastic tiles, semi-flexible and flexible types, as specified in Interim Federal Specification L-T-751 (GSA-FSS), are recommended for the dining areas of mess halls, especially behind food

dispensing tables and along serving lanes. A hardboard underlayment (see 3.1) should be used on wood subfloors. Flexible-type vinyl floorings are not recommended for concrete floors in direct contact with the ground unless the concrete slab has been waterproofed. Semi-flexible vinyl or asphalt tiles using a cut-back asphalt cement are recommended for such locations.

Vinyl plastic floorings have very good resistance to abrasion, reasonably satisfactory indentation characteristics, are impervious to water, and are outstanding in resistance to grease, oils and alkalis. Like most smooth-surfaced floors, they are slippery when wet.

Excessive amounts of water should be avoided when washing any resilient-type floor covering (see 2.2). A mop moistened with water or dilute synthetic detergent solution will remove minor soils. Polishing the floor with No. 000 steel wool will prevent wax build-up, remove some soils, and frequent washing of the entire floor area may not be necessary. Heavy-trafficked areas, such as serving lanes and street entrances, will require more frequent washing and re-waxing (see discussion of waxes in 2.3).

(B). Galleys, Dish-Washing Rooms, and Preparation Rooms for Raw Foods

Exposures to which floors in these areas are subjected are among the most damaging. The floors are exposed to grease; cooking oils; fatty, vegetable, and fruit acids; frequent scrubbing and cleaning, sometimes with strong alkaline detergents; and around stoves to fairly high temperatures. In many areas, the floors are almost continuously wet. It requires an exceptional floor to withstand such a combination of exposures. Sanitary and safety requirements must also be considered. Some floors, especially magnesium oxychloride compositions and poor quality concrete, are eroded appreciably by continuous exposure to water alone.

Where a structurally-sound concrete slab is present, quarry tile with special acid-resistant mortar joints is probably the more durable type of covering. In view of the prevailing wet conditions in these areas, a slip-resistant, abrasive-type tile is recommended as a suitable compromise between sanitary and antislip characteristics. Quarry tiles have excellent resistance to wear and require no protective coatings. Waxing such floors materially reduces their slip resistance, even under dry conditions.

Magnesium oxychloride compositions should not be used in any areas where continuous or appreciable exposure to water is likely. Resilient-type floor coverings are not recommended for these areas

due to the likelihood of failures in adhesion to the subfloor. Also, contact with hot cooking utensils will damage such floor coverings.

From surveys of installations in commercial establishments, the following monolithic-type flooring materials appear to have suitable characteristics for use in areas covered by 3.3-B:

Concrete topping with a properly-proportioned, all-emery aggregate. When placed over a wood subfloor, a reinforcing mesh should be used. The surface of a concrete subfloor must be clean and rough in order to secure an adequate bond between the two floorings. Old concrete floors should be thoroughly scarified and cleaned. Over a concrete subfloor, a thickness of 3/4 inch is recommended; with a wood subfloor, a reinforced slab not less than 1-1/2 inches thick should be installed.

Synthetic resin latex-alumina cement composition, not less than 1/4 inch thick. The subfloor must be absolutely clean and free from grease or other foreign matter before installing the bond coat for this type of material.

3.4 Hospitals

(A). Administration and Recreation Areas.

The discussions and recommendations in 3.1 are applicable for these areas in hospitals.

(B). Corridors.

Traffic along corridors in hospitals, while appreciable, is not of a severe nature, so that the sanitary and slip-resistant characteristics of the floor warrant greater consideration than resistance to wear. Also the floors are not subjected to severe indenting loads.

Terrazzo floors are used extensively in corridors of hospitals of permanent construction and have proven very satisfactory. Abrasive aggregates, such as silicon carbide and aluminum oxide, incorporated in the terrazzo mixture in sufficient amount or sprinkled and rolled into the surface of the mix before final set, will improve the slip resistance of the floor, especially when wet. All ramps should contain an abrasive or slip-resistant aggregate. Since terrazzo floors have excellent resistance to wear and have inherent decorative appeal, waxing terrazzo floors is not recommended due to the probability of creating a slippery walkway surface for patients, visitors, and hospital personnel. Terrazzo sealers or penetrating sealers having a low viscosity are recommended for porous surfaces. Strong alkaline solutions or caustic preparations should not be used to clean terrazzo floors. A neutral soap or preferably a synthetic detergent solution should be used, followed by a rinsing with clean water. Pre-wetting a terrazzo floor with water before applying detergents is beneficial

in that it reduces absorption and lessens the injurious action of salts crystallizing in the pores of the terrazzo.[4/]

The following flooring materials are recommended for covering corridors in unsatisfactory condition, especially in hospitals of temporary construction:

Burlap-backed linoleum, 1/8 in. thick, or felt-backed vinyl plastic flooring with a wearing surface not less than 0.03 in. thick. Over a strip-wood subfloor, a hardboard underlayment should be used. Rough concrete surfaces should be made even with a troweled-on, latex-type underlayment.

Vinyl plastic floorings are much more resistant to alkaline detergents than linoleum. Synthetic detergent solutions should be used to clean linoleum floors. Occasional application of a thin coat of slip-resistant water-emulsion wax along with systematic polishing with No. 000 steel wool to prevent wax build-up and improve slip-resistance are recommended as maintenance procedures. In order to further prevent wax build-up, do not apply fresh wax along edges of corridor when rewaxing. Buffing will spread sufficient wax to such areas. Traffic should not be permitted on freshly waxed areas until the wax is thoroughly dry. Applying wax in thin coats and buffing

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4/ "Terrazzo as Affected by Cleaning Materials", by D.W. Kessler, Journal of the American Concrete Institute, V. 20, No. 1, Sept. 1948 (Title No. 45-3).

materially decreases the time required for a wax to dry. One side of a corridor should be waxed at a time and this portion roped off to traffic and the slip hazard designated by precautionary signs. It cannot be over-emphasized that waxed, smooth-surfaced floors are extremely slippery when wet (see 2.3).

(C). Wards

The wear resistance of floors in wards is not of major importance. Of more importance are such properties as resistance to indentation, slip resistance, and sanitation. Also, this is one location where decorative appeal, even though subjective, is worthy of consideration.

Where floors need to be covered rather than refinished due to sanitation requirements, indentation damage, or unsatisfactory appearance, resilient-type floor coverings are recommended. Comments in 3.1 on the selection and installation of resilient floor coverings are applicable. In view of the importance of sanitation in wards and the likelihood of caustic and disinfectant solutions being used as cleansing agents, vinyl plastic floor coverings are considered preferable. Also, vinyl plastic floors require a minimum amount of waxing in order to maintain a satisfactory appearance.

In some locations, it may be economically feasible to recondition the existing floor and install a floor covering only along the

central aisle between two rows of cots. Resilient-type floor coverings should be protected against severe indenting loads (see Fig. 1).

(D). Mess Halls and Diet Kitchens

The recommendations given in 3.3 for the dining areas of mess halls should be followed for similar areas in hospitals as well as diet kitchens. Recommendations in 3.3 for galleys, dish-washing rooms, and food-preparation rooms also apply to such areas in hospitals.

(E). Laundry Rooms, Lavoratories, and Latrines

Floors in these rooms are usually exposed to appreciable spillage of water and therefore frequently wet for prolonged periods. Recommendations in 3.3 for mess halls should serve as a guide for floors in these rooms. The painting of concrete floors is not recommended as the length of service of such coatings is very limited. Repainted surfaces will show objectionable lap marks at worn areas and are likely to be slippery where built-up coatings exist, especially when wet.

(F). Operating Suites

Since explosive mixtures of gases and vapors are likely to exist in operating suites, floors in these areas require special consideration. Sources of ignition for which the floor may be responsible are percussion sparks and sparks from accumulations of static electricity. Percussion sparks can be avoided by selecting

flooring materials which do not contain a coarse mineral filler or aggregate. Accumulations of electrostatic charges may be prevented by properly installing a conductive flooring conforming to Recommended Safe Practice for Hospital Operating Rooms, N.F.P.A. Standard No. 56, 1952, published by National Fire Protection Association, 60 Batterymarch Street, Boston 10, Massachusetts. References to other literature on explosion hazards in operating suites and recommended specifications for conductive floors are listed below. 5,6,7,8/

(G). Dispensaries

Floors in dispensaries frequently require severe cleansing treatments in order to keep them in a sanitary if not sterile condition. Since vinyl plastic floor coverings possess an outstanding resistance

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5/ "Low-Cost Conductive Flooring for Hospitals", by N. L. Griffin, The Construction Specified, July 1949.

6/ "Report of Committee on Explosions in Hospital Operating Suites", January 1, 1950, Public Buildings Service, General Services Administration, Washington 25, D. C.

7/ "Static Electricity in Hospital Operating Suites: Direct and Related Hazards and Pertinent Remedies", by P. G. Guest, V. W. Sikora and B. Lewis, Bureau of Mines Report of Investigations 4833, January 1952, U. S. Department of the Interior, Washington 25, D.C.

8/ "Progress Report on Conducting Waxes", by W. W. Walton, E. G. Borchardt, F. L. Hermach, and Miss R. C. McAuliff, National Bureau of Standards Report 2046, November 10, 1952, to Bureau of Ordnance, Department of the Navy, Washington 25, D.C.

to caustic solutions and many other reagents, they are recommended for use in dispensaries. They are highly unabsorptive and require a minimum amount of maintenance.

3.5 Floor Areas Exposed to Heavy Trucking, Impacts, Oils and Acids

The following recommendations are based on limited surveys of commercial installations:

A concrete topping with a properly-graded, all-emery aggregate. This material is very dense and unabsorptive. It has a high compressive strength, good resistance to abrasion, and fair slip-resistance when wet. The emery aggregate is not affected by many acids. Over a concrete subfloor, a thickness of 3/4 inch is recommended. The surface of the concrete subfloor must be clean and rough in order to secure an adequate bond between the two floorings. Old concrete floors should be thoroughly scarified and cleaned. Over a wood subfloor, a reinforced slab not less than 1-1/2 inches thick should be installed.

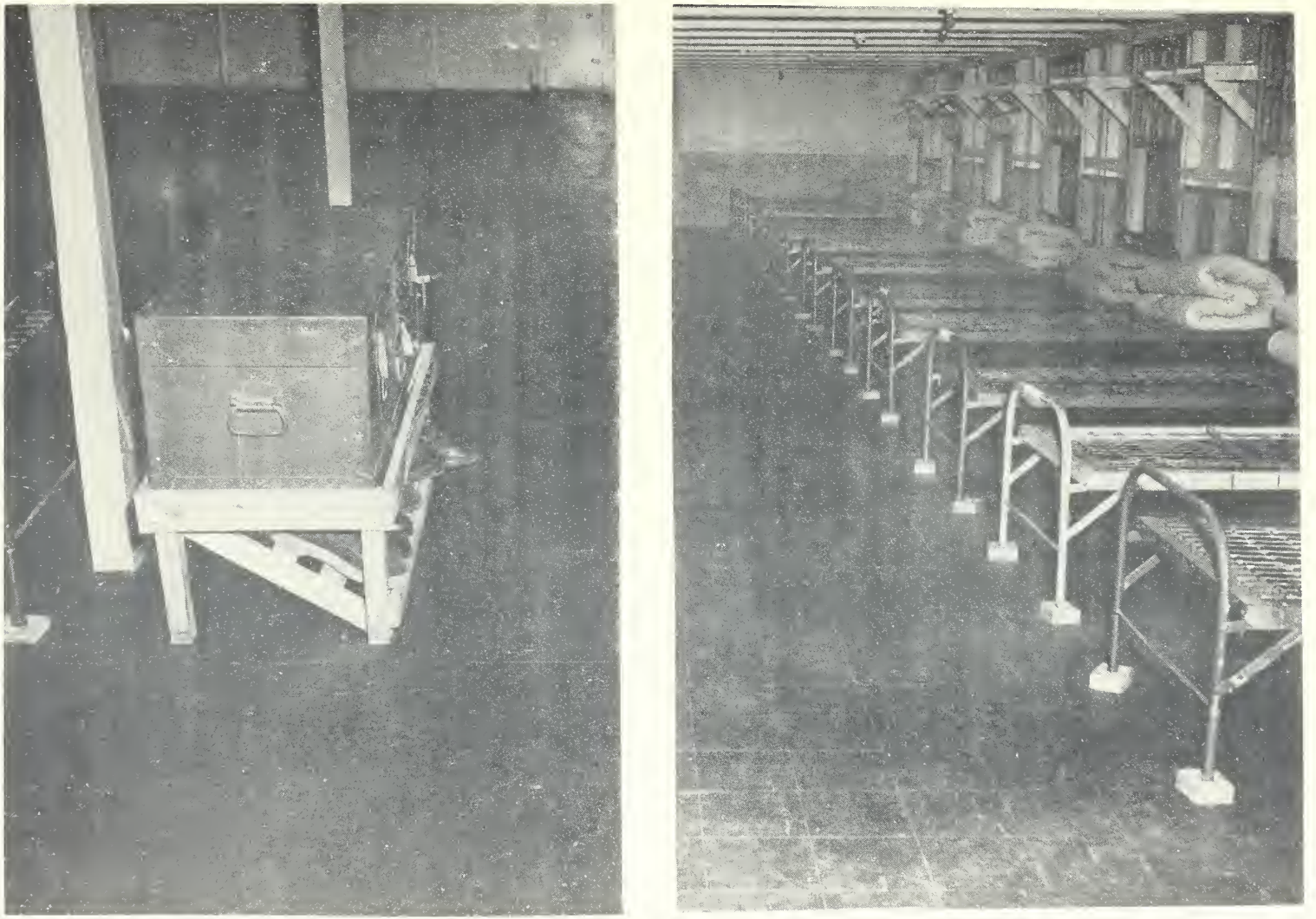

Figure 1. Foot locker stand and bed post blocks used to protect resilient-type floor coverings against severe indenting loads.

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