NZS 3114:1987

New Zealand Standard

Specification for concrete surface finishes

1987 edition of NZS 3114:1980 incorporating Amendment No. 1

STANDARDS NEW ZEALAND

Paerewa Aotearoa

NZS 3114:1987

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COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the Concrete Industry Sectional Committee (31/-) for the Standards Council, established under the Standards Act 1965.

The Concrete Surface Finishes Committee (31/6) was responsible for the preparation of the Standard and consisted of representatives of the following organizations:

Association of Consulting Engineers New Zealand
Building Research Association of New Zealand
Ministry of Works and Development
New Zealand Institute of Architects
New Zealand Institute of Clerks of Works
New Zealand Master Builders' Federation
New Zealand Portland Cement Association
New Zealand Prestressed Concrete Institute

Mr K Orams was co-opted to assist the committe in its work.

Amendment No. 1 was prepared under the direction of the Building and Civil Engineering Divisional Committee (30/-) for the Standards Council. The amendment was approved by the Concrete Construction Advisory Group (30/G/6).

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AMENDMENTS

No	*Date of issue*	*Description*	*Entered by, and date*

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NOTES

RELATED DOCUMENTS

Reference is made in this document to the following:

NEW ZEALAND STANDARDS

		Clause reference herein
NZS 1900:----	*Model building bylaw*	4.1
NZS 3109:1980	*Concrete construction*	104.1.1, 105.1.4, 105.2.4, C105.2.5, 105.3.4, 105.4.4, 105.5.4, 105.6.3, 105.6.4, C106.1, 304.1, C306.1.
NZS 3111:1986	*Methods of test for water and aggregate for concrete*	202.1
NZS 4251:1974	*Code of practice for solid plastering*	C105.2.4
MP 4212:1979	*Glossary of building terminology*	4.1

AMERICAN CONCRETE INSTITUTE

ACI 116R-78	*Cement and concrete terminology*	4.1

FOREWORD TO NZS 3114:1980

Concrete is a material capable of being produced in a wide range of textures and variations of shade, and is subject to certain inherent surface defects, depending upon the materials, climatic conditions, techniques and equipment used.

Because of these variations, designers and specification writers have had problems of accurately describing their requirements at the pre-tendering stage. The constructor has had similar problems in interpreting their wishes and calculating the relative costs. The intention of this Standard is to provide a means of communication by removing ambiguities as far as is practicable.

Some of the concrete finishes described in this Standard are of a very high standard and consequently they would be very expensive to produce. Their cost would only be justified in very critical locations. During the design stage, consideration should be given to whether the structural requirements of the concrete components may inhibit the placing of the concrete, to the detriment of the surface finish.

In preparing this Standard the committee has used as a base the standard recommendations for concrete surface finishes issued by the New Zealand Portland Cement Association.

The Standard is divided into three Parts covering:

1. Off-the-form surfaces.
2. Exposed aggregate surfaces.
3. Floors, exterior pavements, and inverts.

These Parts contain specification and commentary clauses. Where commentary clauses are used they immediately follow the relevant specification clause.

An appendix describing the various surface blemishes and their probable cause is included.

FOREWORD TO 1987 EDITION

NZS 3114:1987 is a new edition of NZS 3114:1980 incorporating Amendment No. 1.

References have been updated and editorial corrections made. Tolerances for abrupt surface plane variations between adjacent formwork panels have been tightened.

NOTES

NEW ZEALAND STANDARD

Specification for CONCRETE SURFACE FINISHES

1 SCOPE

1.1
This New Zealand Standard classifies concrete finishes for off-the-form surfaces, exposed aggregate surfaces and floors, exterior pavements and inverts.

2 INTERPRETATION

2.1
In this Standard the word "shall" indicates a requirement that is to be adopted in order to comply with the Standard, while the word "should" indicates a recommended practice.

2.2
Cross references to other clauses or clause subdivisions within this Standard quote the number only, for example: "The sample panels cast shall comply with 104.4.1".

2.3
Commentary clauses are printed in *italic* and follow the clauses to which they refer. The numbers of commentary clauses are prefixed with the letter "C".

3 REFERENCES

3.1
The full titles of reference documents cited in this Standard are given in the list of Related Documents immediately preceding the Foreword.

4 DEFINITIONS

4.1
In this Standard, unless inconsistent with the context, all terms shall be those used in the current MP 4212:1979 *Glossary of building terminology*, the current relevant section of NZS 1900 *New Zealand model building bylaw*, or ACI 116R-78 *Cement and concrete terminology*.

4.2
The following definitions shall also apply:

SURFACE FINISH (for floors, exterior pavements, and inverts). Those characteristics developed in the exposed surface of the concrete in the course of applying various methods and combinations of vibrating, screeding, wood and steel floating, texturing and curing.

OFF-THE-FORM CONCRETE SURFACES. Those surfaces primarily produced from formwork, smooth or textured, specially designed and constructed as to strength, shape and surface characteristics.

EXPOSED AGGREGATE FINISHES. Those finishes which have aggregate visible in the concrete surfaces either as a rough surface texture or as a smooth polished surface.

Part 1
Off-the-form surface finishes

101
SCOPE

101.1
This Part covers the classes of off-the-form finishes set out in table 1.

102
SELECTION OF SURFACE FINISH

102.1
The appropriate surface finish shall be selected after initially considering the descriptions contained in table 1 and shall be finally specified by reference to section 105.

C102.1
The surface finish should be selected after considering the relative scrutiny which the surface will receive, its location, purpose and function (structural or non-structural), whether the surface will be covered and having regard to the feasibility of producing the surface.

Account has been taken of various types of blemishes, both physical irregularities and colour variations, which can occur in concrete work. In some instances these blemishes are unwanted and even harmful although in others they are of little or no account.

103
BLEMISHES

103.1
The most common types of blemishes are defined and classified into two main groups:

Colour variations
Physical irregularities

Surface blemishes arising from structural cracking are outside the scope of this Standard.

C103.1
The various types of blemishes which occur on concrete surfaces are described together with their probable causes in tables 4, 5, 6 and 7 of Appendix A.

Table 1
CLASSES OF SURFACE FINISH

Clause reference	*Finish*	*Description*	*Typical uses*
105.1	F1	Surfaces where roughness is not objectionable. No surface treatment is required other than filling tie holes and repair of defective concrete. Colour variations and certain physical irregularities permitted.	Concealed surfaces which are to be covered as in foundations, or in walls to be strapped and lined. Upstream faces of dams that will normally be under water.
105.2	F2	Surfaces which provide a key for plaster and other thick surface coverings.	All types of interior or exterior surfaces.
105.3	F3	All permanently exposed surfaces smooth or textured which are not prominent or subject to close or frequent scrutiny.	Surfaces of buildings and civil engineering structures which will not be seen, or observed only from a distance.
105.4	F4	All smooth or textured surfaces of structures where appearance and accurate alignment is of moderate importance as they will be subject to frequent observation.	Walls, panels, columns, beams, etc. in areas of secondary importance such as basements, workshops.
105.5	F5	All smooth or textured surfaces of structures where appearance and accurate alignment is important as they will be exposed to frequent close scrutiny.	Walls, panels, columns, beams, bridge fascia, piers, soffits, parapets and railings, etc. in areas of greater importance such as office areas, foyers, public areas but where the concrete does not form a feature of the space.
105.6	F6	All smooth or textured surfaces of structures where appearance or accurate alignment and evenness of surface are of the greatest importance.	*Architectural or feature panels and high velocity water channels where it is essential to prevent the destructive effects of water action.

* The latter include portions of outlets, draft tubes and spillway tunnels and channels of high dams where flow velocity exceeds 12 m/s.

104
SURFACE TOLERANCES

104.1
Surface plane variations

104.1.1
General
Tolerances for surface plane variations relate only to the surface condition of the concrete. Structural tolerances are specified in NZS 3109.

104.1.2
Abrupt variations or offsets shall be within the limits specified under the particular class of finish being defined as shown in fig. 1.

C104.1.2
Abrupt variations or offsets are considered to be a surface plane variation within a continuous flat or curved surface. As such they would typically apply at construction joints and joints in formwork materials. These variations are not considered to apply to abrupt changes across the joints of precast concrete panels where it is necessary to consider the tolerances of manufacture and erection of such panels before nominating an acceptable abrupt change tolerance.

104.1.3
Gradual variations shall be within the limits specified under the particular class of finish being defined as shown in fig. 2.

104.2
Colour variations

104.2.1
Colour variations shall comply with the requirements under the particular class of finish.

104.2.2
Where the specifier considers that inherent shade variations are important, then, in association with sample panels as described in 104.4, the specifier shall make reference to the use of the photographic grey scale in fig. 24.

C104.2.2
Inherent shade variations are not normally considered to be important. However, where the specifier has nominated sample panels to be produced, it is recommended that a range of inherent shade variations be agreed between specifier and constructor.

The tolerances for other colour variation factors contained in Appendix A cannot be specified in detail. For this reason it is necessary in finishes requiring special attention to the reduction of colour blemishes to specify the production of sample panels, see 104.4.

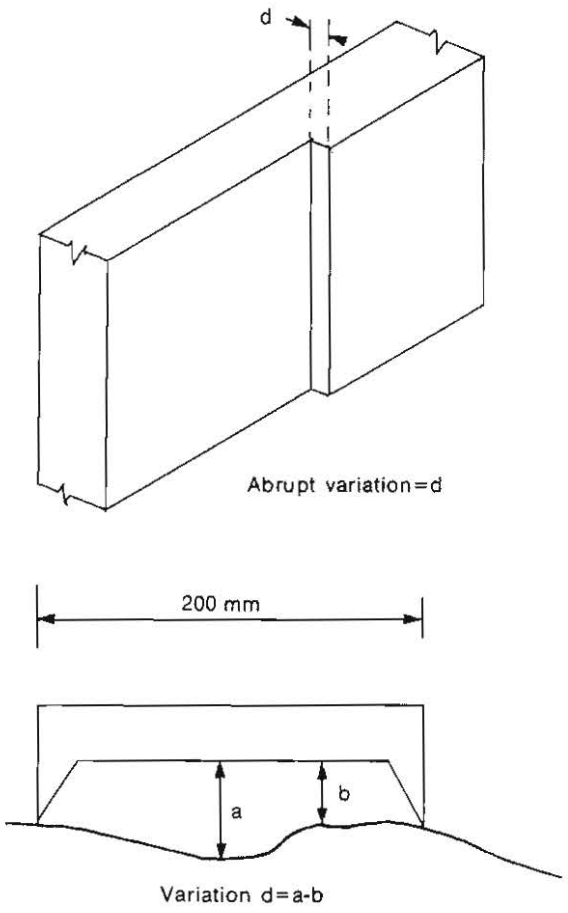


Fig. 1
ABRUPT VARIATIONS OR OFFSETS

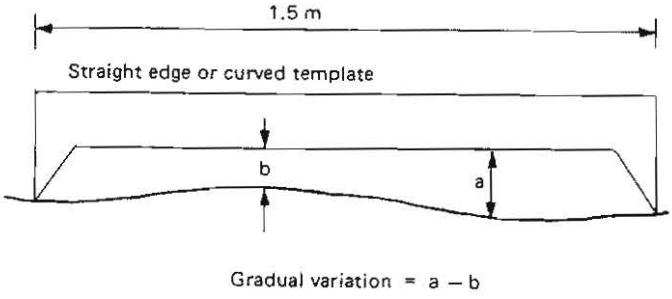


Fig. 2
GRADUAL VARIATIONS

104.3
Physical irregularities

104.3.1
Physical irregularities shall be within the limits specified under a particular class of finish.

104.3.2
The size and frequency of blowholes in the concrete surface shall be assessed by placing the typical range of blowhole sizes and frequency produced at natural size in fig. 25 against the concrete surface and assigning a range of comparisons.

C104.3.2
While the incidence of blowholes can be assessed by a photographic comparison method, tolerances for other physical irregularities contained in Appendix A cannot be specified in detail and it is necessary in finishes requiring special attention to the reduction of such irregularities to specify the production of sample panels see 104.4.

104.4
Sample reference panels

104.4.1
General

104.4.1.1
The specifier shall nominate an existing finish locally available for inspection to both specifier and constructor.

The constructor shall either first make a sample panel to assess the practicability of reproducing the finish or shall agree that the finish as defined can be produced.

The existing finish shall be accurately located and defined by the parties as the agreed standard before permanent construction commences for assessing compliance of the finish on matters not covered by 104.2 and 104.3.

104.4.1.2
In addition, when sample panels are required, the specifier shall specify the number and size required which shall be of a thickness similar to the proposed construction unless specifically amended.

104.4.1.3
The sample panels shall:

(a) Be cast in the same orientation as the finished work is to be cast
(b) Be cast in formwork equal in all respects to that to be used in the finished work
(c) Be cast using the specified concrete mix for the finished work
(d) Be compacted using vibration methods to be used in the work and shall incorporate reinforcement similar to the proposed construction
(e) Have formwork struck at an agreed time after casting consistent with proposed work practice
(f) Be cured by a specific method for a specified period of time, all as consistent with the proposed work practice
(g) Include any rebates required, features, joints between sheeting materials, construction joints and treatment at the hole positions.

104.4.1.4
The following information shall be supplied by the constructor of the sample panel:

(a) Brand and type of cement used
(b) Aggregate used, grading, and source
(c) Water cement ratio
(d) Type of formwork lining
(e) Brand and type of release agent used
(f) Mix quantities
(g) Age at stripping formwork
(h) Extent and type of curing
(j) Admixtures
(k) Grade of concrete.

104.4.1.5
If the sample panels, when viewed at a distance of 3 m, are truly representative of the finish specified, and the constructor considers that finish capable of being produced they shall be used as an agreed standard between the parties before permanent construction commences. As such, they shall also be used for assessing compliance of the finish on matters not covered by 104.2 and 104.3.

104.4.2
Textured and special effects finishes
While 104.4.1 together with the appropriate specified class of finish may be considered satisfactory for the production of plain off-the-form finishes, for textured and special effect finishes, the specifier shall clearly define the requirements of texture and effects required before the production of any sample panels.

C104.4.1 and C104.4.2
The minimum size of sample panel should be 650 mm x 650 mm. The specifier is recommended to call for full size sample panels whenever possible.

It must be appreciated however that full size samples cannot be reasonably expected to be supplied by a constructor during the tender period. Such sample panels are only considered to be part of the awarded contract. For this reason it is particularly important for the specifier to make clear what textured and special effects are required at time of tender. References to established texture should be included

in the tender documents and also, for new and special effects, good quality photographs should be included incorporating a scale rule.

The sample panels showing the agreed standard of finish should be located both at the sites of casting and erection of the building if these are different.

In determining shade variations it is important to consider the time aspects of when to make comparisons. The specifier and constructor should agree to a suitable time after casting, for checking shade variations. Particular care must be emphasized in ensuring that the positioning of sample panels or selection of constructed areas for sample reference, reflects fairly the degree of weathering to be experienced by the finished work and that samples are not subjected to accelerated discolouration due to adjacent construction activities.

The depth of placement determines the pressure on the formwork and influences colour and blowhole frequency. If a sample panel is of lesser height than will occur in placement on site, there is likely to be a different surface finish. The type of concrete vibration can also affect the surface finish; immersion and external vibrators can produce different aggregate distributions.

105
SPECIFICATION OF FINISHES

105.1
F1 finish

105.1.1
General
A finish defined as F1 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F1X in the job specification clause which shall also contain all the special provisions and variations made.

C105.1.1
F1 finish is normally associated with works to be covered. Fig. 5 illustrates a typical finish produced from a plywood former. Board lines and fins from a boarded former would be acceptable.

105.1.2
Surface tolerances
No special requirements for abrupt or gradual variations in surface evenness shall be required.

C105.1.2
While no surface finish evenness tolerances are set, the member constructed must comply with the dimensional tolerances set in NZS 3109.

105.1.3
Colour variations
No special provisions need be made to reduce the incidence of colour variations, banding, surface retardation, efflorescence or dusting.

105.1.4
Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3.1 shall be permitted to vary across the full range No. 1 to No. 7 in fig. 25.
(b) Formwork shall be designed to meet the dimensional tolerances of the member to be formed as set out in NZS 3109.
Any small occurrences of grout loss, honeycombing, and scouring shall be accepted.
(c) No special provisions need be made with the formwork surface or method of striking the forms. Resulting non-structural damage from form scabbling, chipping and spalling shall be accepted.

105.1.5
Surface dressing

(a) All tie holes shall be filled with mortar of proportions 1 part cement to 1½ to 2 parts sand by volume unless specifically excluded.
(b) Where the repair of defects is necessary the repair shall not be required to match the shade or texture of the surrounding concrete.

C105.1.5
While from an appearance point of view some degree of physical irregularities can be permitted, if it is considered that they reduce the protection of items cast in the concrete, for example, or are considered structural defects, then repairs in accordance with NZS 3109 may be required.

105.2
F2 finish

105.2.1
General
A finish defined as F2 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F2X in the job specification clause which shall also contain all the special provisions and variations made.

C105.2.1
F2 finish is normally associated with works to be covered by thick coating, for example, plaster.

Fig. 6 illustrates a typical finish produced from a plywood former. Board lines and fins from a boarded former would be considered to provide additional keying and are thus preferable to plyforms. This finish would not normally be suitable for thin coat paint finishes.

105.2.2
Surface tolerances

(a) Abrupt changes as defined in 104.1.2 shall not exceed 6 mm.
(b) Gradual variations as defined in 104.1.3 shall not exceed 6 mm.

105.2.3
Colour variations

(a) The constructor shall take precautions to avoid the incidence of dusting and efflorescence.
(b) No special provisions need be made to reduce the incidence of colour variations.

C105.2.3
The constructor with reference to Appendix A should consider the probable causes of dusting and efflorescence with a view to minimizing the risk of their occurrence.

105.2.4
Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3.2 shall be permitted to vary across the range No. 1 to No. 7 in fig. 25.
(b) Formwork shall be designed to meet the limiting dimensional tolerances of the member as required by 105.2.2 and NZS 3109.
Any small occurrence of grout loss, honeycombing and scouring shall be accepted.
(c) No special provisions need be made with the formwork surface or method of striking the forms.
Resulting non-structural damage from form scabbling, chipping and spalling shall be accepted.

C105.2.4
While no special provision need be taken with the formwork surface, there is a need to consider that the smoothness of the resulting concrete surface may be unsatisfactory for some plastering applications. Accordingly it is necessary for the specifier to consider the plastering specification before specifying an F2 finish as described. Reference to NZS 4251 is required. Where additional roughness or texture is required then additional requirements should be specified.

105.2.5
Surface dressing

(a) All tie holes shall be filled with mortar of proportions 1 part cement to 1½ to 2 parts sand by volume unless specifically excluded.
(b) Where repair of defects is necessary the repair shall not be required to match the shade or texture of the surrounding concrete.

C105.2.5
While from an appearance point of view some degree of physical irregularities can be permitted, if it is considered that they reduce the protection of items cast in the concrete, for example, or are considered structural defects then repairs in accordance with NZS 3109 may be required.

105.3
F3 finish

105.3.1
General
A finish defined as F3 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F3X in the job specification clause which shall also contain all the special provisions and variations made.

C105.3.1
F3 finish is normally associated with surfaces of building or civil engineering structures which are visible but not subjected to close or frequent scrutiny.

Fig. 7 illustrates a typical smooth finish produced from a plyformer.

105.3.2
Surface tolerances

(a) Abrupt changes as defined in 104.1.2 shall not exceed 6 mm at construction joints, nor 3 mm at joints between adjacent shutters or between abutting sheets of form face material.
(b) Gradual variations as defined in 104.1.3 shall not exceed 6 mm.

105.3.3
Colour variations

(a) The constructor shall take precautions to avoid the incidence of dusting and efflorescence.

(b) No special provisions need be made to reduce the incidence of other colour variations.

C105.3.3
The constructor with reference to the Appendix A should consider the probable causes of dusting and efflorescence with a view to minimizing the risk of their occurrence.

105.3.4
Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3.2 shall be permitted to vary across the range No. 1 to No. 5 in fig. 25.
(b) Formwork shall be designed to meet the limiting dimensional tolerances as required by 105.3.2 and NZS 3109.
(c) The constructor shall take precautions both to reduce grout loss leading to honeycombing and to avoid the incidence of scouring.
(d) The constructor shall take precautions with the formwork surface, and method of striking the formwork, to avoid the incidence of damage by form scabbling, chipping and spalling.

C105.3.4
The constructor should consider the various requirements of the formwork to ensure that grout loss is not great enough to create honeycombing. This requires that formwork deflections under load, particularly at construction joint positions, should be limited.

105.3.5
Surface dressing

(a) All form tie holes shall be filled with mortar of proportions 1 part cement to 1½ to 2 parts sand to match the parent concrete unless specifically excluded.
(b) Where the repair of minor defects is necessary, the repair shall be required to match as near as is practicable the shade of the surrounding concrete.
(c) Bagging or stoning of the surface shall be permitted. The method nominated shall receive prior approval of the specifier.

C105.3.5
In this regard it is advisable to fill such holes as early as possible after removal of formwork. It must however be accepted by the specifier that perfect matching of shade cannot always be obtained in the practical situation.

105.4
F4 finish

105.4.1
General
A finish defined as F4 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F4X in the job specification clause which shall also contain all the special provisions and variations made.

C105.4,1
F4 finish is normally associated with an exposed smooth or textured surface of moderate importance which will be exposed to close scrutiny.

Fig. 8 illustrates a typical smooth surface produced to this class of finish.

It is considered that sample panels are essential to the specification and control of work in this class of finish. The constructor should, having produced sample panels, ensure that consistent practice for the full scale production of the finish follows the methods and materials tabulated under 104.4.

105.4.2
Surface tolerances

(a) Abrupt changes as defined in 104.1.2 shall not exceed 4 mm at construction joints nor 2 mm at joints between adjacent shutters or between abutting sheets of form face material.
(b) Gradual variations as defined in 104.1.3 shall not exceed 6 mm.

105.4.3
Colour variations

(a) The limits of acceptance of colour variations shall be based upon sample panels as defined in 104.4.
(b) The constructor shall take precautions to avoid the incidence of discolouration, contamination, dusting, retardation and efflorescence.

C105.4.3
The constructor with reference to Appendix A should consider the probable causes of discolouration, contamination, dusting, retardation and efflorescence to minimize the risk of their occurrence.

105.4.4
Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3 shall be permitted to vary across the range No. 1 to No. 4 in fig. 25.
(b) Formwork shall be designed to meet the limiting dimensional tolerances as required by 105.4.2 and NZS 3109 providing that the maximum allowable formwork deflection is 1/270 of the clear span between studs, ties

or struts or 3 mm whichever is the smaller.

The position of form tie joints between sheeting material and construction joints shall be notified to the specifier by the constructor in advance of formwork fabrication and receipt of specifier's approval.

(c) The constructor shall take precautions both to eliminate grout loss leading to honeycombing and to avoid the incidence of scouring.

(d) The constructor shall take precautions with the formwork to avoid the incidence of damage by form scabbling, chipping and spalling.

C105.4.4

The constructor should consider the various requirements of formwork to ensure that grout loss is in the main eliminated. This requires that formwork deflections under load particularly at construction joint positions should be strictly limited. The use of sealing strips may be required. The constructor should carefully consider the use of release agents.

105.4.5

Surface dressing

(a) The specifier shall specify the filling or treatment of all tie holes.

(b) Where the repair of minor defects is necessary this shall be required to match the shade and texture of the surrounding concrete, as near as is practicable.

(c) Bagging or stoning of the surface shall be permitted. The method nominated shall receive prior approval of the specifier.

C105.4.5

Particular attention must be paid to the treatment of tie holes, and their general appearance. For this reason the specifier must give clear instructions at the time of tender as to the method of treating tie holes and restraints on tie hole pattern.

The assessment of minor defects is related to the sample panels provided. However the standard finish to be achieved is required to be formed direct from the formwork with a minimum of attention to the stripped surface.

105.5
F5 finish

105.5.1

General

A finish defined as F5 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F5X in the job specification clause which shall also contain all the special provisions and variations made.

C105.5.1

F5 finish is normally associated with an exposed smooth or textured surface which will be exposed to close scrutiny.

Fig. 8 illustrates a typical smooth surface produced to this class of finish.

It is considered that sample panels are essential to the specification and control of work in this class of finish. The constructor should, having produced sample panels, ensure that consistent practice for the full scale production of the finish follows the methods and materials tabulated under 104.4.

105.5.2

Surface tolerances

(a) Abrupt changes as defined in clause 104.1.2 shall not exceed 2 mm at construction joints nor 1 mm at joints between adjacent shutters or between abutting sheets of form face material.

(b) Gradual variations as defined in 104.1.3 shall not exceed 6 mm.

105.5.3

Colour variations

(a) The limits of acceptance of colour variations shall be based upon sample panels as defined in 104.4.

(b) The constructor shall take precautions to avoid the incidence of discolouration, contamination, dusting, retardation and efflorescence.

C105.5.3

The constructor with reference to Appendix A should consider the probable causes of discolouration, contamination, dusting, retardation and efflorescence to minimize the risk of their occurrence.

105.5.4

Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3 shall be permitted to vary across the range No. 1 to No. 3 in fig. 25.

(b) Formwork shall be designed to meet the limiting dimensional tolerances as required by 105.5.2 and NZS 3109 providing that the maximum allowable formwork deflection is $\frac{1}{270}$ of the clear span between studs, ties or struts, or 3 mm, whichever is the smaller.

The position of form tie joints between sheeting material and construction joints shall be notified to the specifier by the constructor in advance of formwork fabrication

and receipt of the specifier's approval.

(c) The constructor shall take precautions both to eliminate grout loss leading to honeycombing and to avoid the incidence of scouring.

(d) The constructor shall take precautions with the formwork to avoid the incidence of damage by form scabbling, chipping and spalling.

C105.5.4

The constructor should consider the various requirements of formwork to ensure that grout loss is in the main eliminated. This requires that formwork deflections under load particularly at construction joint positions should be strictly limited. The use of sealing strips may be required. The constructor should carefully consider the use of release agents.

105.5.5

Surface dressing

(a) The specifier shall specify the filling or treatment of all tie holes.

(b) Where the repair of minor defects is necessary this shall be required to match as near as is practicable the shade and texture of the surrounding concrete.

(c) Bagging or stoning of the surface shall be permitted. The method nominated shall receive prior approval of the specifier.

C105.5.5

Particular attention must be paid to the treatment of tie holes, and their general appearance. For this reason the specifier must give clear instructions at the time of tender as to the method of treating tie holes and restraints on tie hole pattern.

The assessment of minor defects is related to the sample panels provided. However the standard finish to be achieved is required to be formed direct from the formwork with a minimum of attention to the stripped surface.

105.6

F6 finish

105.6.1

General

A finish defined as F6 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F6X in the job specification clause which shall also contain all the special provisions and variations made.

The specifier shall require the production of samples by the constructor in accordance with the requirements of 104.4.

C105.6.1

F6 finish is normally associated with an exposed, smooth or textured surface which will be exposed to highest and detailed scrutiny on a building or structure.

The finish is also applicable to high velocity water channels having a minimum velocity of 12 m/s.

It is considered that sample panels are essential to the specification and control of work in this class of finish. The constructor should, having produced sample panels, ensure that consistent practice for the full scale production of the finish follows the methods and materials tabulated under 104.4.

The attention of both the specifier and constructor should be drawn to the fact that this finish is to have the minimum of surface blemishes. The specifier in selecting an F6 finish should be aware that this highest quality work requires expert experienced attention on the part of the constructor. It is important therefore to choose judiciously the areas of a structure to be designated as F6 finish since there may well be areas or positions in a structure where there are practical difficulties of achieving the finish.

The purpose of 105.6 is to bring about both an agreed standard of finish being compatible with practical methods being available to produce such a finish. In this regard a mutual understanding of problems of achieving the finish are required by both the specifier and constructor.

Fig. 9 illustrates a typical smooth surface produced to this class of finish.

105.6.2

Surface tolerances

(a) Abrupt changes as defined in 104.1.2 shall not exceed the following:

Architectural	1 mm at construction joints, 0.5 mm at joints between adjacent shutters or between abutting sheets of form face material,
High velocity water channels	3 mm not parallel to flow 6 mm parallel to flow

(b) Gradual variations as defined in 104.1.3 shall not exceed 4 mm.

C105.6.2

The tolerances listed in respect of architectural uses are extremely small being based upon the production of a smooth surfaced concrete where shadow effects are particularly important. Where the specifier requires the same degree of freedom from blemish in the surface but is utilizing a textured surface then the specifier should consider increasing the permitted tolerances as allowed under 105.6.

105.6.3
Colour variations

(a) The limits of acceptance of colour variations shall be based upon sample panels as defined in 104.4.
(b) The constructor shall take precautions to avoid the incidence of discolourations, contamination, dusting, retardation, and efflorescence.
(c) The formwork design shall in addition to considering the requirements of 105.6.2, and 105.6.4 take into account the special requirements of rigidity and NZS 3109.

C105.6.3
The constructor with reference to Appendix A should consider the probable causes of discolouration, contamination, dusting, retardation, and efflorescence to minimize and eliminate where possible these defects. The range of possible blemishes can be effected by material variations outside the control of the constructor. Nevertheless it is the responsibility of the constructor to use his best endeavour to regulate all matters liable to effect the surface finish. The constructor is advised at the time of the production of sample panels to bring to the attention of the specifier particular matters of potential variations.

105.6.4
Physical irregularities

(a) The incidence of blowholes as ascertained by the method described in 104.3 shall be permitted to vary across the range No. 1 to No. 2 in fig. 25.
(b) Formwork shall be designed to meet the limiting dimensional tolerances as required by 105.6.2, rigidity requirements of clause 105.6.3 and structural tolerances of NZS 3109 provided that the maximum allowable formwork deflection is 1/360 of the clear span between studs, ties, or struts or 2 mm whichever is the smaller. The position of form ties, joints between sheeting materials, and construction joints shall be notified to the specifier by the constructor in advance of formwork fabrication.
(c) The constructor shall prevent grout loss and scouring.
(d) The constructor shall take precautions with the formwork surface and method of striking to prevent damage from form scabbling, chipping and spalling.

C105.6.4
The constructor should consider the various requirements of the formwork to ensure that grout loss is eliminated. The formwork would necessarily be of joinery quality incorporating sealing strips at joints.

The constructor should carefully consider the use of release agents.

105.6.5
Surface dressing

(a) The specifier shall specify the filling or treatment of all tie holes and restraints on tie hole pattern.
(b) Bagging, stoning or other repairs of the surface shall be carried out only with the prior approval of the specifier.
(c) On high velocity water channels where the velocity of flow is 12 m/s, or greater, abrupt offsets shall be ground down to the following requirements:
  (i) Grind abrupt offsets not parallel to flow exceeding 3 mm as follows:

  Velocity of flow

12 to 27 m/s	1 in 20 height to length
27 to 36 m/s	1 in 50 height to length
over 36 m/s	1 in 100 height to length

  (ii) Grind abrupt offsets parallel to flow exceeding 6 mm 1 in 20 height to length.

C105.6.5
Particular attention must be paid to the treatment of tie holes, and their general appearance. For this reason the specifier must give clear instructions at the time of tender as to the method of treating tie holes and restraints on tie hole pattern.

The assessment of minor defects is related to the sample panels provided.

It is emphasized that it is envisaged that this highest quality surface is to be produced direct from the formwork with a minimum of acceptable blemishes requiring a minimum of treatment to the surface.

106
MATERIALS AND WORKMANSHIP

106.1
Material selection
The selection of materials shall take into account the class of finish to be produced.

C106.1
Since the quality of concrete surfaces produced will be dependent upon the materials used, careful selection is required by specifier and constructor.

While the concrete mixes specified in NZS 3109 are essentially related to structural requirements without specific considerations of additional requirements where finishing operations are involved, the classification and grades of concrete adopted nevertheless has application for various standards of surface finish.

Finishes are affected by such matters as concrete grades, cement content, workability, formwork, release agents, concrete placement, compaction, curing, protection, finishing and dressing. Useful references are contained in Appendix B.

106.2
Responsibility
The constructor shall be responsible for determining the method of producing the specified finished work.

106.3
Performance
The constructor shall be responsible for ensuring that the execution of the work at all times shall be carried out and supervised by personnel skilled in the production of the class of finish specified.

106.4
Protection
Protection of the specified finish shall be provided and maintained where necessary during any handling, erection or subsequent construction operations to ensure that the surface finish is clean and undamaged upon completion of work.

C106.4
Details of any protection scheme should be made available to the specifier prior to commencing construction.

Where the constructor is not the general contractor then the responsibility for providing details of any protection scheme to the specifier is that of the general contractor who should include pertinent matters relating to the constructor's responsibility in this matter. It is necessary for the constructor therefore to indicate clearly the extent and type of protection work provided.

Particular attention is drawn to the need to protect surfaces from rust staining arising from construction reinforcement or steel lifting loops in the case of precast units.

It may be desirable on precast panels of the highest quality finish to use non-exposed or non-corrosive lifting devices and use galvanized steel for projecting reinforcing steel.

Part 2
Exposed aggregate surfaces

201
SCOPE

201.1
This Part sets out the requirements for exposed aggregate surfaces including those for pavements.

202
SELECTION OF SURFACE FINISH

202.1
The selection of an exposed aggregate surface shall where possible be related to a visual sample or completed example of a concrete surface of the colour and texture required.

202.2
The specification of the materials for producing an exposed aggregate surface shall consider the following:

(a) *Aggregates* –

- (i) The petrographic analysis of the aggregate for suitability for weathering (see NZS 3111) and staining
- (ii) The colour and mineral type of aggregate required
- (iii) The source of the material, if known
- (iv) Maximum aggregate size or sizes and the grading
- (v) Depth of exposure required
- (vi) The basic characteristics of the aggregate, for example, crushed or rounded pebbles
- (vii) Compatibility with cements either plain or with colour pigmentation added
- (viii) The requirements of standardizing the source of supply of materials.

(b) *Matrix* –

- (i) The colour and texture of the matrix
- (ii) The thickness and nature of the matrix to ensure adequate bonding of aggregate to the matrix, and bonding of the matrix to any backing concrete where used.

C202.2
The selection of a suitable exposed aggregate finish relates to various matters of the appearance, size and durability of the exposed aggregate particles as well as to the method of producing the exposed surface.

The need to consider petrographic analysis, accelerated weathering and staining is particularly emphasized. There exist test procedures under NZS 3111 for considering weathering. While evidence of use is a strong indicator of performance, it is advised that tests should be carried out when changes in size of material are contemplated from the existing example. The use of gap graded aggregate results in a more defined exposure of the large aggregate.

203
BLEMISHES

203.1
The most common types of blemish are divided into two main groups:

Colour variations
Physical irregularities

203.2
Surface blemishes arising from structural cracking are outside the scope of this Standard.

C203
The various types of blemishes which occur on concrete surfaces are described together with their probable causes in tables 4 to 7 of Appendix A.

204
SURFACE TOLERANCES

204.1
Tolerances for surface plane variations relate only to the surface condition of the concrete. Structural tolerances are specified in NZS 3109.

204.1.1
Abrupt variations
Abrupt variations shall be in accordance with the limits specified under a particular class of finish being defined as shown in fig. 1.

C204.1.1
As described in C104.1.1

204.1.2
Gradual variations
Gradual variations shall be in accordance with the limits specified under the particular class of finish being defined as shown in fig. 2.

204.2
Colour variations
Colour variations shall be assessed by comparison with sample panels produced in accordance with 104.4 when viewed from an equal distance.

C204.2
Only a visual comparison can be obtained. Accordingly the constructor should, when producing sample panels, give some indication of likely variation between samples.

As colour and quality variations do occur in the supply of naturally occurring aggregates, it is

advisable to ensure that the total volume of aggregate is purchased prior to commencing production. It is very likely the final bulk supply may differ from the aggregate used in the sample panels.

204.3
Physical variations
Physical irregularities shall be within the limits specified under a particular class of finish.

204.3.1
The size and frequency of blow holes shall be assessed as set out in 104.3.2. Other physical irregularities shall be assessed by comparison with sample panels produced in accordance with 104.4 when viewed from an equal distance.

205
SPECIFICATION OF FINISHES

205.1
The exposed aggregate finish, after being described in accordance with section 202, shall be designated F4E, F5E or F6E after consideration of table 1, for inclined or vertical walls or designated U5E for floors or pavements. The suffix E denotes that the aggregate is to be exposed on the surface.

C205.1
The use of off-the-form finish designations is considered appropriate in the light that the majority of such finishes can be created from a formed surface. The fact that in many precasting methods panels are produced horizontally, with an unformed upper surface being the exposed aggregate surface, does not alter the formal appearance or acceptance of the final finish of the panel.

205.2
F4E, F5E and F6E finish
A finish defined as F4E, F5E or F6E shall be formed to the respective requirements of 105.4, 105.5 or 105.6 unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated F4EX, F5EX or F6EX as appropriate in the job specification clause which shall also contain all the special provisions and variations made.

205.3
U5E finish
A finish defined as U5E shall be formed to the requirements of 305.2 unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated U5XE in the job specification clause which shall also contain all the special provisions and variations made.

206
MATERIALS AND WORKMANSHIP

206.1
Materials and workmanship shall be in accordance with 106.1 to 106.4 inclusive.

Part 3
Floors, exterior pavements, and inverts

301
SCOPE

301.1
This Part covers the classes of surface finish for those concrete surfaces that are unformed except at the perimeter, and which are not laid in a vertical plane but generally in a horizontal plane for floors and may be sloping in one or more directions for other surfaces.

C301.1
This section covers interior and exterior construction.

Interior construction *generally comprising floor elements can be considered in three categories.*

(a) *Slabs on prepared subgrade namely, basement floor slabs, ground floor slabs.*
(b) *Top surfaces of suspended floor slabs.*
(c) *Top surfaces of concrete topping, namely, toppings to precast concrete units, clay units, waffles or pan units, steel decking or similar elements.*

Exterior construction, *which may be edge slip formed, covers a wide range of use. Examples are footpaths, yards, roads and airfield runways, taxiways and hardstandings, inverts of tunnels, spillways, siphons, flumes, canal structures, canal lateral linings.*

This part includes finishes for both hand-placed and machine-laid pavements and inverts.

301.2
The classes of surface finish are set out in table 2.

C301.2
Typical examples are illustrated in figures 10 to 23.

302
SELECTION OF SURFACE FINISH

302.1
The appropriate surface finish shall be selected after considering the descriptions contained in table 2, having regard to the purpose, appearance, performance and durability required.

C302.1
For floors the selection of the appropriate surface finish must be related to the purpose of the floor surface and the possible use of floor coverings.

For other surfaces, special attention should be given to the degree of frictional resistance or smoothness required and the means by which this is to be achieved. Bearing in mind, for example, the need for adequate practical drainage to minimize aqua-planing on roads and runways, sample panels should be cast and the surface approved.

303
BLEMISHES

303.1
The most common types of blemish are defined into two main groups:

Colour variations
Physical irregularities

Surface blemishes arising from structural cracking are outside the scope of this Standard.

C303.1
The various types of blemish which occur on concrete surfaces are described together with their probable causes in tables 4, 5, 6, and 7 of Appendix A.

304
SURFACE TOLERANCES

304.1
Surface plane variations

304.1.1
Tolerances for surface plane variations relate only to the surface condition of the concrete. Structural tolerances are specified in NZS 3109.

304.1.2
Abrupt variations or offsets shall be in accordance with the limits specified in table 3 relating the particular class of finish to the proposed use, being defined as shown in fig. 3.

C304.1.2
Abrupt variations are considered to be a surface plane variation within a continuous flat or curved surface. As such they could typically apply at construction joints.

304.1.3
Gradual variations shall be in accordance with the limits specified in table 3 relating to the particular class of finish to the proposed use being defined as shown in fig. 4.

304.2
Colour variations
Colour variations shall comply with the requirements under the particular class of finish.

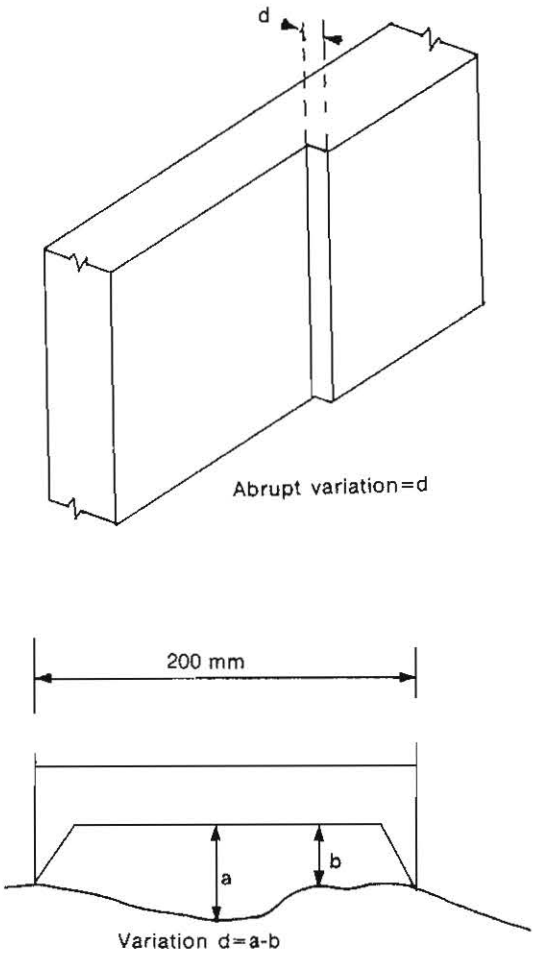


Fig. 3
ABRUPT VARIATIONS OR OFFSETS

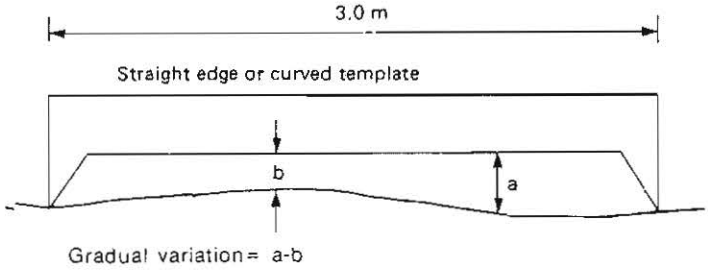


Fig. 4
GRADUAL VARIATIONS

304.2.1
Where the specifier considers that inherent shade variations are important, then, in association with sample panels as described in 104.4, the specifier shall make reference to the use of the photographic grey scale in fig. 24.

C304.2
Inherent shade variations are not normally considered to be important. However, where the specifier has nominated sample panels to be produced, it is recommended that a range of inherent shade variation be agreed between specifier and constructor.

The tolerances for other colour variation factors contained in Appendix A cannot be specified in detail. For this reason it is necessary, in finishes requiring special attention to the reduction of colour blemishes, to specify the production of sample panels (see 304.4).

304.3
Physical irregularities
Physical irregularities shall be within the limits specified under a particular class of finish.

C304.3
Tolerances for physical irregularities contained in Appendix A cannot be specified in detail. It is necessary, in finishes requiring special attention to the reduction of such irregularities, to specify the production of sample panels (see 304.4).

304.4
Sample reference panels

304.4.1
General

304.4.1.1
When sample panels are required, the specifier shall specify the number and size required which shall be of a thickness similar to the proposed construction unless specifically amended.

304.4.1.2
The sample panels cast shall comply with 104.4.1 as appropriate but in addition shall indicate the methods employed on the surface to achieve the specified finish.

304.4.1.3
Once accepted that the sample panels as viewed at a distance of 1.5 m are truly representative of the finish envisaged by the specifier and that the sample panels are considered to be truly representative of the practicability of producing such a finish by the constructor, the panels shall be used as an agreed standard between the parties before permanent construction commences for assessing compliance of the finish on matters not covered by 304.2.

Table 2
CLASSES OF FLOOR, EXTERIOR PAVEMENT, AND INVERT FINISHES

Class	*Finish*	*Technique*	*Examples*
U1	Screeded	Hand sawing motion with straightedge or mechanical vibrating screed.	Finishes covered by backfill or concrete. Footpaths, yards and driveways. First stage for placement.
U2	Floated	Wood or bull float, or both. Generally manual but power driven equipment may be used.	As for U1 where a higher standard of finish is required. Floors to receive carpets with underlay or similar coverings. Inverts of syphons, flumes, floors of canal structures, spillways outlet works and stilling basins. Surfaces which are intended for use by ambulant or wheelchair-bound persons.
U3	Trowelled	Manual or mechanical steel trowelling of floated finish after the concrete is sufficiently hardened, to prevent excess fine material and water being worked to the surface, may be done in one or two stages depending on degree of smoothness required.	Direct wearing floors such as factories, warehouses and processing plants. Floors to receive thin sheet coverings, carpet and similar coverings. Inverts of water, tunnels and tunnel spillways. Not generally used for pedestrian or vehicular traffic where a smooth finish could be dangerous in ice or wet conditions. Is not suitable even when dry, for surfaces which are intended for use by ambulant disabled or wheelchair-bound persons. See U2.
U4	Machine screeded	Vibrating or oscillating screed or vibrating plate, or both, which may be supplemented by long handled metal, wooden, or rubber floats.	Used for durability where resistance to erosion and cavitation under action of high velocity water is especially required; and as first and second stage finishing for roads and airfield pavements prior to texturing with U5, U6 or U8 finishes.
U5	Shallow textured	Hard or soft bristled brooms.	Footpaths, yards, driveways, roads, pavements for aircraft.
U6	Deep textured	Wire broom or rubber tyning.	Surface to receive a subsequent bonded concrete topping. Roads and runways where greater frictional resistances are required than can be obtained by U5 finish.
U7	Grooved	Saw cutting or flailing by mechanical means.	Treatment to existing roads and runways to provide frictional resistance and drainage paths for run-off to minimize aquaplaning.
U8	Grooved	Mechanical grooving the fresh concrete surface after compaction and surface screeding techniques.	Roads and runways.
U9	Scabbled	Mechanical hammering of hardened concrete.	Can be used on any pavement surface to produce a textured effect or to reduce high surfaces to the correct level or to rectify out-of-tolerance pavements.
U10	Special textured	The use of equipment to give special effects.	Architectural effects on pavements and slabs, produced by rollers with drums of expanded metal, or profiled tampers on screedboards, and the like.
U11	Ground finish	Low speed coarse stone grinding to remove thin weak surface layers/minor ridges and to produce an even "glasspaper" textured surface, that is, not a polished surface. Used as a second stage finish to U2, approximately 36 to 48 h after laying.	Direct wearing floors such as factories and warehouses.

Table 3
TOLERANCES FOR ABRUPT DEVIATIONS OR OFFSETS AND GRADUAL DEVIATIONS

Abrupt deviation

Maximum abrupt deviation shall be 3 mm for all classes of finish and use except where otherwise shown in brackets.

Gradual	*Gradual deviations in mm*										
Use	*U1*	*U2*	*U3*	*U4*	*U5*	*U6*	*U7*	*U8*	*U9*	*U10*	*U11*
(a) Interior — Floors											
(1) Exposed concrete		5	5								5
(2) Covered — Thin sheet tiles			3(0)								3(0)
(3) Covered — Carpet			5(0)								5(0)
(4) Covered — Levelling compound		5									
(b) Exterior											
(1) Footpaths, yards, driveways	10(5)	5	5	5	5	5			5	5	
(2) Roads	3	3		3	3	3	3	3	3	5	
(3) Aircraft pavements	3	3		3	3	3	3	3	3		
(4) Water channels velocity < 12 m/s		6	6								
(5) Water channels high velocity $\geqslant 12$ m/s				6							
(6) Parallel to flow				6(6)							

NOTE — Where the tolerances for abrupt deviation have been exceeded then the grinding of the surface —

(a) Shall be required for high velocity water channels as follows:

(1) Grind abrupt offsets across direction of flow exceeding 3 mm as follows:

Velocity of flow	*Grinding level into flow*
12 to 27 m/s	1 in 20 height to length
28 to 36 m/s	1 in 50 height to length
over 36 m/s	1 in 100 height to length

(2) Grind abrupt offsets parallel to the flow exceeding 6 mm, 1 in 20 height to length;

(b) Shall be permitted as follows:

(1) Floor surfaces to be covered with thin sheets such as tiles or carpet; offsets ground to 1 in 50 height to length.

In order to produce the highest quality surface to receive thin sheet materials, proprietary levelling compounds may be used. In such cases it is recommended that U2 finish be specified;

(c) Shall not be permitted on any other finish without the prior approval of the specifier.

304.4.1.4
When sample panels are not required the specifier shall nominate an existing finish locally available for inspection to both specifier and constructor.

304.4.1.5
The constructor shall either first make a sample panel to assess the practicability of reproducing the finish or shall agree that the finish as defined can be produced.

304.4.1.6
The existing finish shall be accurately located and defined as the agreed standard between the parties before permanent construction commences for assessing compliance of the finish on matters not covered by 304.2.

304.4.2
Textured and special effect finishes
The specifier shall clearly define the requirements of texture and effects required before the production of sample panels.

C304.4.1 and C304.4.2
The minimum size of sample panel should be 650 mm x 650 mm. The specifier is recommended to call for full width samples whenever possible so that the full scale effects of construction methods can be ascertained.

It must be appreciated however that full size samples cannot be reasonably expected to be supplied by a constructor during the tender period. Such sample panels are only considered to be part of the awarded contract. For this reason it is particularly important for the specifier to make clear what textured and special effects are required at the time of tender. References to established texture should be included in the tender documents and also for new and special effects good quality photographs should be included, incorporating a scale rule.

The acceptability of textured surfaces such as broomed pavements can be ascertained by comparison with plaster or neoprene casts of the desired texture. "Negative" plaster casts of existing textured surfaces, which have been approved for the particular pavement use, are taken and from these "negatives", "positive" neoprene casts can be produced as an acceptable sample of the specified surface texture.

305
SPECIFICATION OF FINISHES

305.1
U1 finish

305.1.1
General
A finish defined as U1 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated U1X in the specification clause which shall also contain all the special provisions and variations made.

C305.1.1
U1 finish is normally associated with work left direct from the application of screeding the surface. Fig. 10 illustrates a typical example.

305.1.2
Surface tolerances
The surface tolerances of abrupt and gradual deviations as defined in 304.1.1 and 304.1.2 shall be as set out for a range of uses in table 3.

C305.1.2
Where for example some special use is required, the specifier must specify the variations as allowed under 305.1.

305.1.3
Colour variations

(a) The constructor shall take precautions to avoid oil discolouration and contamination
(b) No special provisions need to be made to reduce the existence of other colour variations.

C305.1.3
The constructor with reference to Appendix A should consider the probable causes of oil discolouration and contamination, with a view to minimizing the risk of their occurrence.

305.1.4
Physical irregularities

(a) The constructor shall take precautions to prevent plastic cracking
(b) Formwork shall be removed in such a way as to minimize damage to the upper arris of construction joints.

C305.1.4
The constructor with reference to Appendix A should consider the causes of plastic cracking to minimize its occurrence.

305.2
U2, U5, U6, U7, U8, U9, U10, U11 finishes

305.2.1
General
A finish defined as U2, U5, U6, U7, U8, U9, U10 or U11 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated U-X in the specification clause which shall also contain all the special provisions and variations made.

C305.2.1
The specifier by using the appropriate suffix number can indicate the type of textured finish required.

U2, U5, U6, U7, U8, U9, U10, U11 finishes are normally associated with work created from the initial use of a wood or bull float, or both. Figures 11 and 12 illustrate typical examples of textured surfaces. Textured surfaces U6, U7, U8, U9, U10 and U11 are illustrated in figures 15, 16, 17, 18, 19, 20, 21, 22 and 23.

305.2.2
Surface tolerances
The surface tolerances of abrupt and gradual deviations as defined in 304.1.1 and 304.1.2 shall be as set out for a range of uses in table 3.

C305.2.2
Where, for example, some special use is required, the specifier must specify the variations as allowed under 305.2.

305.2.3
Colour variations
The constructor shall take precautions to prevent the occurrence of dusting, oil discolouration and contamination. No special precautions need be made to reduce the incidence of inherent shade variations and dye discolouration.

C305.2.3
The constructor with reference to Appendix A should consider the probable causes of dusting, oil discolouration and contamination with a view to minimizing their occurrence.

305.2.4
Physical irregularities
The constructor shall take precautions to prevent grout loss, mortar loss, laitance and dishing, and to restrict the uncontrolled formation of shrinkage cracks.

C305.2.4
The constructor with reference to Appendix A should consider the probable causes of grout loss, mortar loss, laitance and dishing, with a view to minimizing their occurrence. Causes of plastic cracking should be studied to prevent its occurrence. The specifier and constructor both have responsibilities for ensuring that shrinkage effects are controlled in a satisfactory manner. In relation to probable causes reference should be made to Appendix A wherein both design and construction matters are listed. It is important for the specifier to ensure that adequate instructions are given to the constructor in respect to the spacing and requirements of control joints.

305.3
U3 and U4 finishes

305.3.1
General
A finish defined as U3 or U4 shall be formed to the requirements of this clause unless special provisions or variations have been made by the specifier.

Where the specifier departs from the standard requirements, the finish shall be designated U3X or U4X in the specification clause which shall also contain all the special provisions and variations made.

C305.3.1
The specifier by using the appropriate suffix number can indicate the types of textured finish required.

U3 is normally associated with work created from the use of steel trowelling which can be manual or power motivated in a sweeping or rotary action.

U4 is normally associated with work created from a steel finishing beam having an essentially sawing motion.

Figures 13 and 14 illustrate typical U3 and U4 finishes respectively.

305.3.2
Surface tolerances
The surface tolerances of abrupt and gradual deviations as defined in 304.1.1 and 304.1.2 shall be as set out for a range of uses in table 3.

C305.3.2
Where, for example, some special use is required, the specifier should specify the variations as allowed under 305.3.

305.3.3
Colour variations
The constructor shall take precautions to prevent the occurrence of dusting, oil discolouration and contamination. No special precautions need be made to reduce the incidence of inherent shade variations and dye discolouration.

C305.3.3
The constructor with reference to Appendix A should consider the probable causes of dusting, oil discolouration and contamination with a view to minimizing their occurrence.

305.3.4
Physical irregularities
The constructor shall take precautions to prevent grout loss, mortar loss, laitance, dishing,

waviness and ridges. He shall take precautions, to eliminate the formation of plastic cracks and crazing, and to restrict the uncontrolled formation of shrinkage cracks.

C305.3.4
The constructor with reference to Appendix A should consider the probable causes of grout loss, mortar loss, laitance, dishing, waviness and ridges, with a view to eliminating their occurrence. Causes of plastic cracking and crazing should be studied to prevent its occurrence. The specifier and constructor both have responsibilities for ensuring that shrinkage effects are controlled in a satisfactory manner. In relation to probable causes reference should be made to Appendix A wherein both design and construction matters are listed. It is important for the specifier to ensure that adequate instructions are given to the constructor in respect of the spacing and requirements of control joints.

306
MATERIALS AND WORKMANSHIP

306.1
Material selection
The specification and selection of materials shall take into account the class of finish to be produced.

C306.1
Since the quality of concrete surfaces produced will be dependent upon the materials used, careful selection is required by specifier and constructor.

While the concrete mixes specified in NZS 3109 are essentially related to structural requirements without specific considerations of additional requirements where finishing operations are involved the classification and grades of concrete adopted nevertheless has application for various standards of surface finish.

Finishes are affected by such matters as concrete grades, cement content, workability, formwork, release agents, concrete placement, compaction, curing, protection, finishing, and dressing. Useful references are contained in Appendix B.

306.2
Responsibility
The constructor shall be responsible for determining the method of producing the specified finished work.

306.3
Performance
The constructor shall be responsible for ensuring that the execution of the work shall be at all times carried out and supervised by personnel skilled in the production of the class of finish specified.

306.4
Protection
Protection of the specified finish shall be provided and maintained where necessary during any handling, erection or subsequent construction operations to ensure that the surface finish is clean and undamaged upon completion of work.

C306.4
Details of any protection scheme should be made available to the specifier prior to commencement of construction.

Where the constructor is not the general contractor then the responsibility for providing details to the specifier of any protection scheme is that of the general contractor who should include pertinent information relating to the constructor's responsibility in this matter. It is necessary for the constructor therefore to indicate clearly the extent and type of protection work provided.

APPENDIX A
BLEMISHES IN CONCRETE

A1
Various types of blemish which can occur on concrete surfaces are described together with their probable causes in tables 4, 5, 6 and 7.

A2
It is important for the specifier when preparing the specification, and the constructor when considering the methods necessary to meet the specification, to consider the probable causes of blemishes and their possible elimination or reduction.

Table 4
COLOUR VARIATIONS
(Early age of concrete)

Blemish	*Description*	*Most probable causes*
Inherent colour variation	Variation in colour of the surface	Materials: Inconsistent grading, colour or source, aggregate transparency, material changes. Concrete: Incomplete mixing, segregation, or variation in proportions, ingredient omission
Hydration discoloration (due to moisture movement within or from the fresh concrete)	Variation in shade of the surface	Formwork: Variable absorbency, through joints, variable vibration Release agent: Uneven or inadequate application Curing uneven
Dye discoloration	Discoloration foreign to the constituents of the mix	Formwork: Stains, dyes or dirt on the form face Release agent: Impure Materials: Dirty
Oil discoloration	Cream or brown discoloration	From construction plant Release agent: Excessive; impure (applied too late to the formwork) Timber or plywood inhibition
Retardation	Matrix near the colour of sand and lacking in durability	Formwork: Retarder in or on form face; timber or plywood retardation Release agent: Water soluble emulsion: cream or oil with excessive surfactant (surface active agent). Unstable cream; unsuitable or excessive chemical release agent
Banding	Texture or colour variation showing in bands, generally in the horizontal plane in the members	Due to inconsistency in the concrete placement, stop-start methods in either conventional or slipforming concrete placing behind the forms, different hydration conditions

Table 5
COLOUR VARIATIONS
(Later ages of concrete)

Blemish	*Description*	*Most probable causes*
Drying discoloration	Variation in shade of surface from light to dark	Curing: Different conditions Reinforcement: Inadequate cover
Lime bloom or efflorescence	White powder or bloom on the surface	Design: Permitting uneven washing by rain Leaching action Release agent: Type Curing: Uneven conditions
Contamination	Discoloration foreign to the colour of constituent materials	Materials: Pyrites, clay or other impurities Construction plant Embedded steel: Inadequate cover; rust from steel above Curing: Impure curing compounds; dirty covers
Dusting	Light-coloured dusty surface, which may weather to expose aggregate	Curing: Inadequate (very rapid drying) Vibration: Excessive vibration causing formation of laitance on surface Excessive trowelling too early Cement: Air-set Release agent: Excessive application

Table 6
PHYSICAL IRREGULARITIES
(Early age of concrete)

Blemish	*Description*	*Most probable causes*
Honeycombing	Coarse stone surface with air voids and lacking fines	Concrete mix: Insufficient fines; workability too low Formwork: Joints leaking Placing methods: Segregation, compaction inadequate Design: Highly congested reinforcement, section too narrow
Blowholes	Individual cavities usually less than 12 mm diameter. Small cavities approximately semi-spherical. Larger cavities often bounded by stone particles	Formwork: Form face impermeable with poor wetting characteristics; inclined; too flexible Release agent: Neat oil without surfactant Concrete mix: Too lean: sand too coarse; workability too low Placing methods: Inadequate compaction; rate of placing too fast; ineffective external vibration
Grout loss	Sand textured areas devoid of cement. Usually associated with dark colour on adjoining surface	Formwork: Leaking at joints. tie holes, stop-ends, and similar defects
Scouring	Irregular eroded areas and channels having exposed stone or sand particles	Concrete mix: Excessively wet; insufficient fine particles: too lean Placing methods: Water in formwork: excessive vibration on wet mix; low temperature when placing
Steps	Step, wave or other deviation from the intended shape	Formwork: Damaged, deformed under load; joints not tightly butted - poorly designed Placing methods: Too rapid or careless
Plastic cracking	Short cracks often varying in width along their length	Concrete mix: High water-cement ratio; low sand content; uneven moisture retention prior to curing Compaction: Uneven compaction Ambient conditions leading to high evaporation rate and moisture loss from concrete Reflective cracking above reinforcement due to insufficient concrete cover Movement of partially set concrete; sloping conditions

Table 6 continued

Blemish	*Description*	*Most probable causes*
Form scabbling	Parts of the form face, including barrier paint, adhering to the concrete	Formwork: Form face excessively rough, weak, or damaged Release agent: Ineffective, inadequate application or removed during subsequent operations Striking time: Too late
Laitance	Milkiness — surface accumulation of porous weak cement paste	Placing methods: Excessive vibration; premature floating Concrete mix: Unsatisfactory or excessively wet, or both
Ridges or waviness	Physical deviations from the intended shape	Sideforms: Lack of rigidity Finishing methods: Insufficient care during floating and screeding operations
Dishing	Noticeable slumping of parts of surface	Placing: Uneven compaction Finishing: Screeding and power floating techniques Sub-base: Insufficient preparation

Table 7
PHYSICAL IRREGULARITIES
(Later ages of concrete)

Blemish	*Description*	*Most probable causes*
Scaling	Thin layer of hardened mortar removed from the concrete surface, exposing mortar or stone	Formwork: Relaxing after compaction; form face excessively rough Release agent: Ineffective application or removed during subsequent operations Concrete: Low strength; placing over vibration of high slump concrete. Striking time — too early
Spalling or chipping	Pieces of concrete removed from the hardened surface. Deeper and usually more severe than scaling	Formwork: Difficult to strike Release agent: Ineffective, inadequate application or removed during subsequent operations Concrete: Low strength — aggregates susceptible to damage by frost or water Striking time: Too early; mechanical damage after striking Weathering: Frost action — corrosion or reinforcement
Crazing	A network of fine cracks in random directions, breaking the surface into areas from about 6 mm to 75 mm across	Formwork: Form face of low absorbency, smooth, or polished Concrete mix: Too rich in cement, too high water-cement ratio Curing: Inadequate Striking time: Too early, especially in cold weather Compaction: over-vibration
Scouring and abrasion	Surface material washed away by fluid action and Surface material removed by rubbing action of solid bodies	Curing: Inadequate protection (water cure too severe, rainwater access) Concrete mix: Aggregates with insufficient abrasion resistance; lack of adhesion in mix; segregation; surface hardness treatment insufficient for purpose
Holes	Irregular cavities	Concrete mix: Presence of soft, light materials such as wood and seedpods
Warping	Deviation from the intended shape	Curing: Temperature and shrinkage differentials, the latter due to variation in water retention

Table 7 continued

Blemish	*Description*	*Most probable causes*
Shrinkage cracks	Usually transverse cracks, partly or wholly across slabs	Concrete mix design: Water/cement ratio, aggregate/cement ratio Incorrect design of slabs; slabs unable to slide on sub-base due to excessive frictional resistance during curing; saw cutting joints too late Excessive moisture loss through surface or into sub-base. Inadequate protection during hydration and hardening

APPENDIX B
OTHER SOURCES OF INFORMATION

B1
The following references will provide guidance in the selection and production of various concrete surface finishes:

New Zealand Concrete Research Association:

IB033 Specification and Production of Concrete Surface Finishes, 1983
IB018 Architectural Surface Finishes 1982
IBO26 Concrete Floor for Commercial and Industrial Use, 1984
IB29 Formwork, 1986
IB037 Weathering of Concrete Buildings, 1981
IB41 Formwork detailing, 1982

Building Research Association of New Zealand:
Technical Paper P22Blowholes in Concrete Cast In-situ, 1978

Cement and Concrete Association, U.K.:
BLAKE, L.S.
Recommendations for the Production of High Quality Concrete Surfaces
BLAKE, L.S.; KINNEAR, R.G.; and MURPHY, W.R.
Recent research into Factors Affecting the Appearance of In-situ Concrete (Symposium), 1964
GAGE, Michael
Guide to Exposed Concrete Finishes, 1970
KINNEAR, R.G.
Concrete Surface Blemishes, 1964
MONKS, W.L.
An Investigation into the Incidence of Colour Variation in Formed Concrete Surfaces, 1974 (Technical Report 42.493)
MURPHY, W.E.
The Influence of Concrete Mix Proportions and Type of Form Face on the Appearance of Concrete, 1967 (TRA 384)
TILLER, R.M. (WARD, F.W.) WILSON, J. Gilchrist
Concrete Finishes for Highway Structures, 1972
Specification Clauses Covering the Production of High Quality Finishes to In-situ Concrete, 1970

American Concrete Institute:

ACI SP4 Formwork for Concrete
ACI 308-78 Standard Practice for Curing Concrete (MCP-2, Manual of Concrete Practice, Part 2)
ACI 347-78 Recommended Practice for Concrete Formwork (MCP-2)
ACI 210-55 Erosion Resistance of Concrete in Hydraulic Structures (MCP-1)
ACI SP2 Manual of Concrete Inspection (7th edition), 1981.

Cement and Concrete Association of Australia:

MORRISH, C.F.
Control of Surface Finishes in Concrete Cast Vertically, 1967
MORRISH, C.F.
A Review of Techniques and Possibilities in Architectural Off-the-form Concrete Finishes, 1964

CSIRO:

LEWIS, R.K.
The Influence of Release Agents and Formwork on Concrete Surface Finishes Report C3.4-1, 1972

International Council for Building Research, Studies and Documentation, Rotterdam:

CIB Report No. 5	The Production of Concrete of Uniform Colour and Free from Surface Blemishes, 1966
CIB Report No. 24	Tolerances on Blemishes on Concrete, 1973.

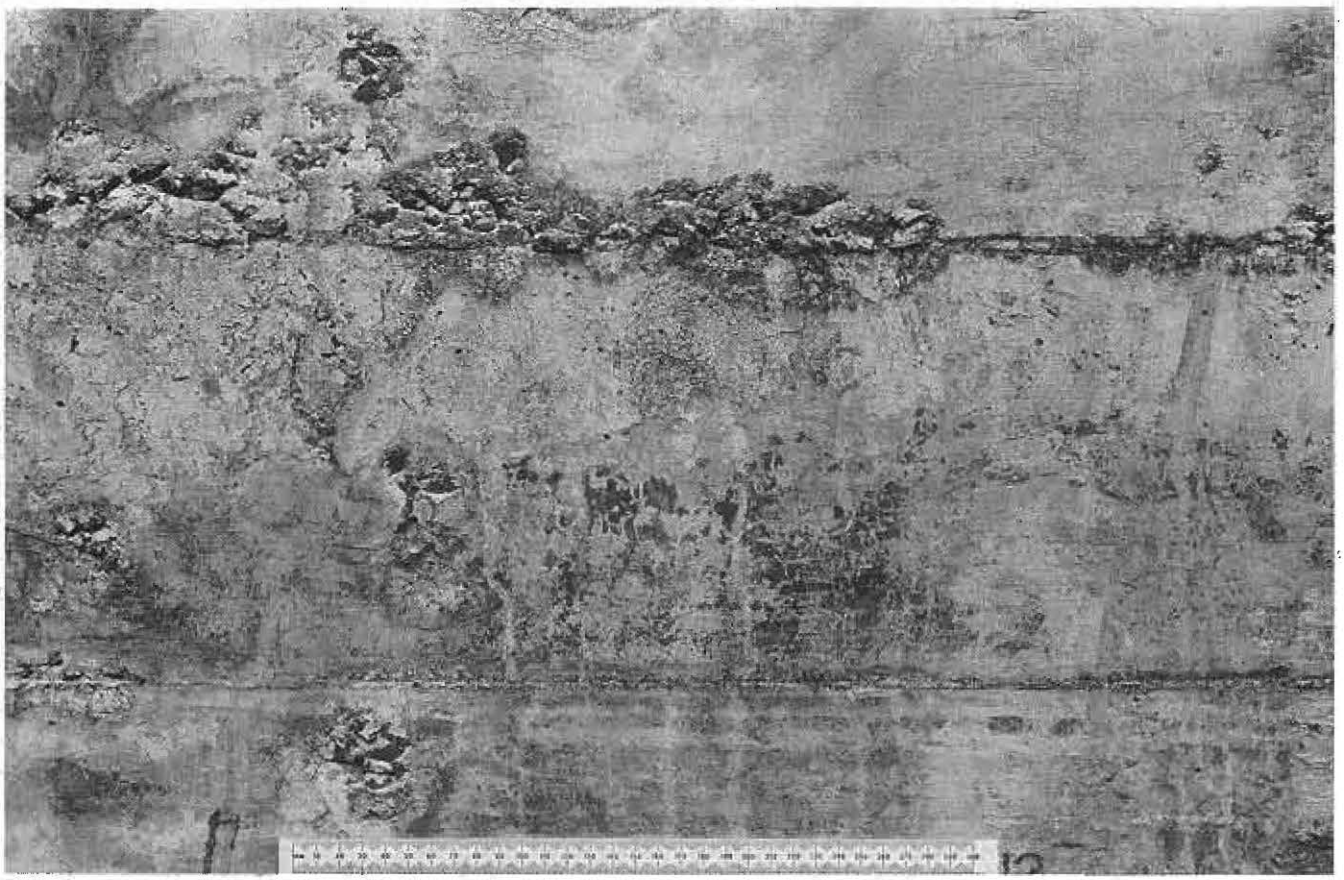


Fig. 5
PHOTOGRAPH OF TYPICAL SURFACE ILLUSTRATING CLASS F1 OFF-THE-FORM FINISH

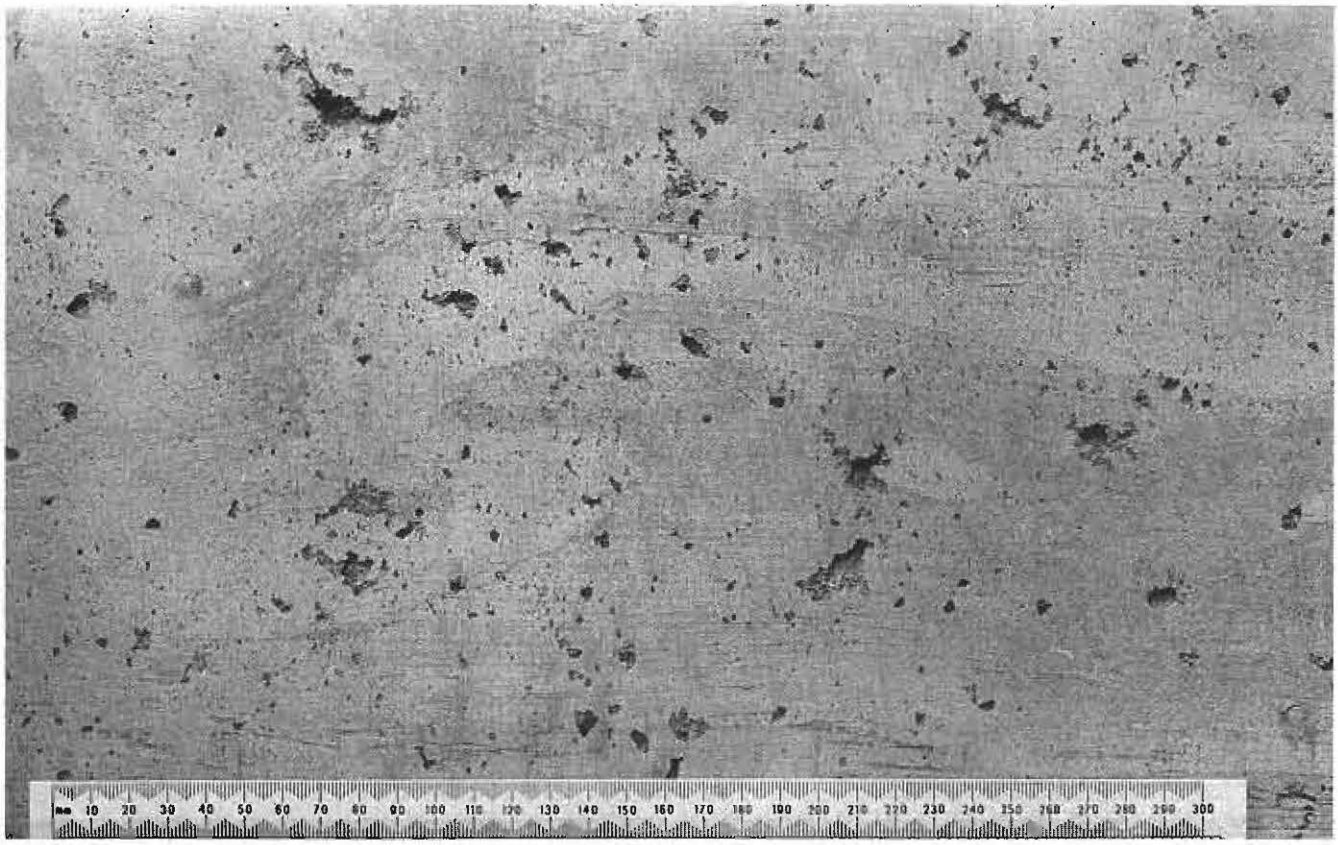


Fig. 6
PHOTOGRAPH OF TYPICAL SURFACE ILLUSTRATING CLASS F2 OFF-THE-FORM FINISH

Fig. 7
PHOTOGRAPH OF TYPICAL SURFACE ILLUSTRATING CLASS F3 OFF-THE-FORM FINISH

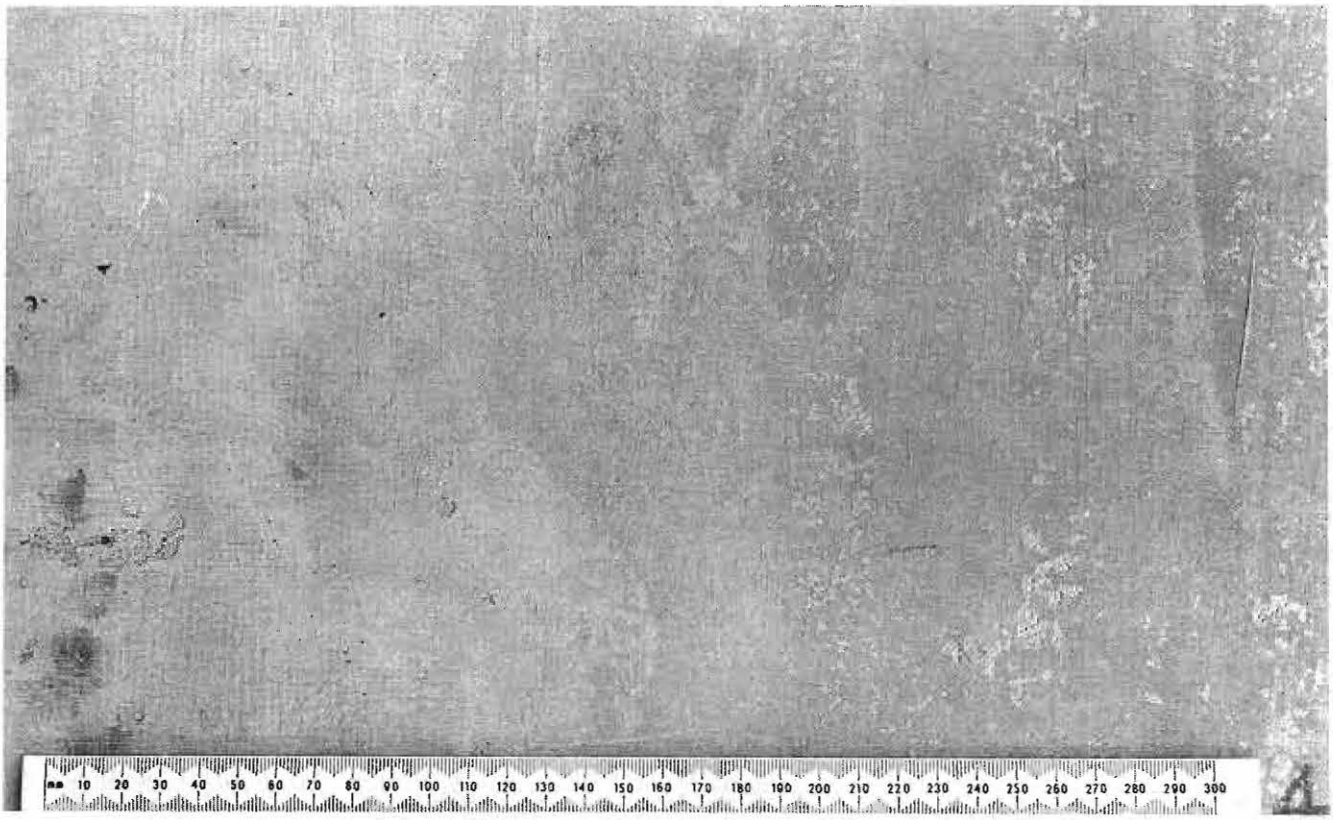


Fig. 8
PHOTOGRAPH OF TYPICAL SURFACE ILLUSTRATING CLASS F4 and F5 OFF-THE-FORM FINISH

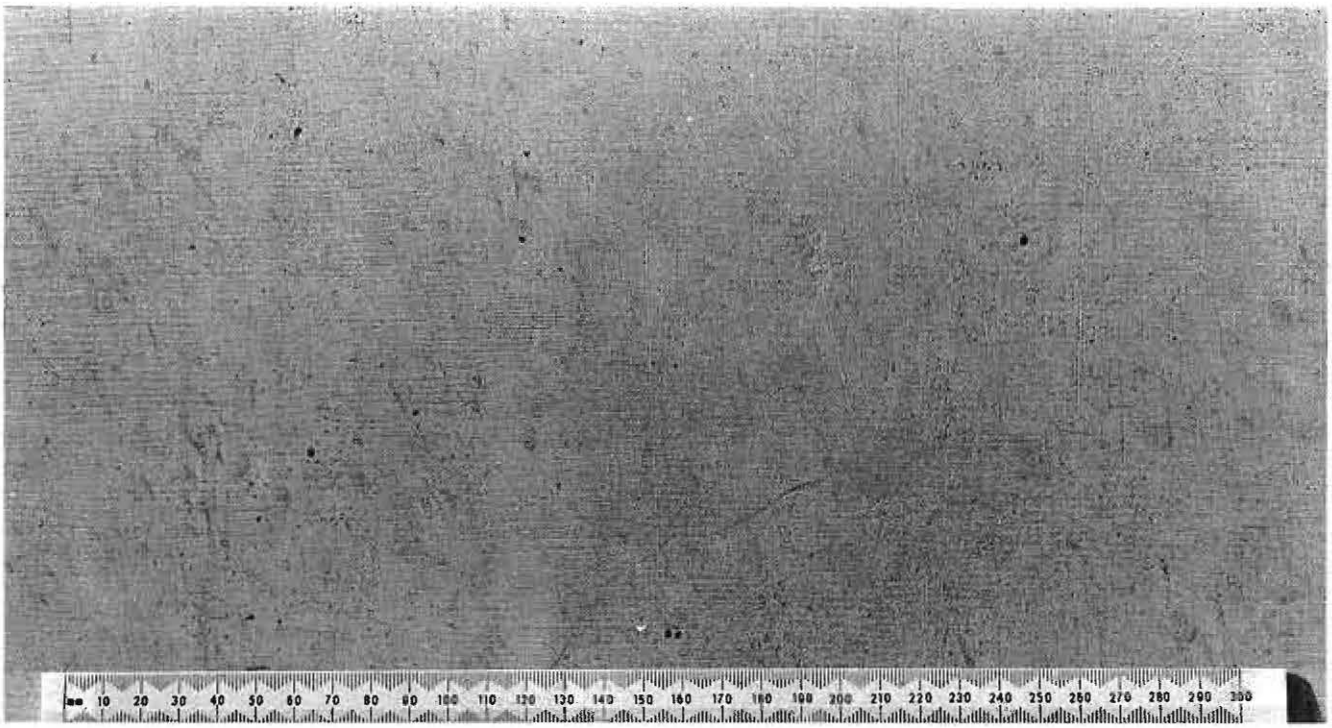


Fig. 9
PHOTOGRAPH OF TYPICAL SURFACE ILLUSTRATING CLASS F6 OFF-THE-FORM FINISH

CLASSES OF PAVEMENT AND FLOOR FINISHES
Typical examples

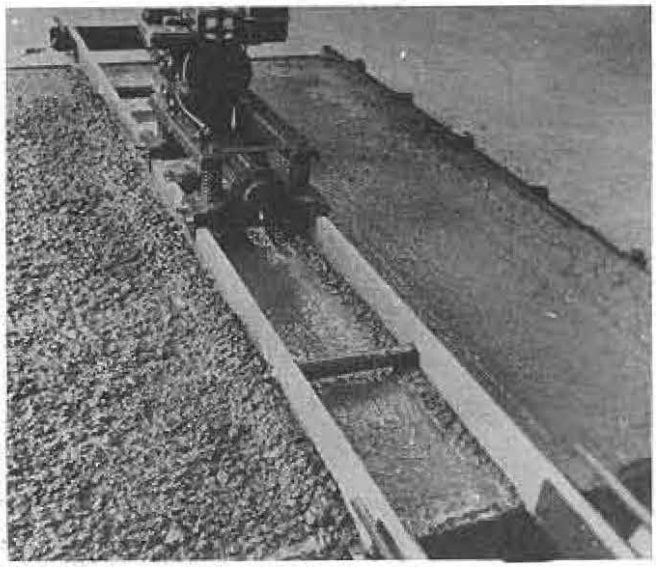
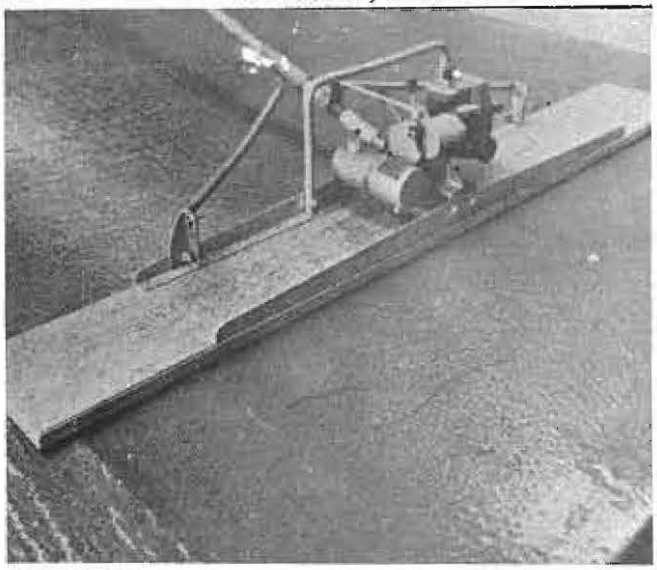


Fig. 10
CLASS U1, SCREEDED



Vibrated float

Bull float

Fig. 11
CLASS U2, FLOATED (MANUAL)

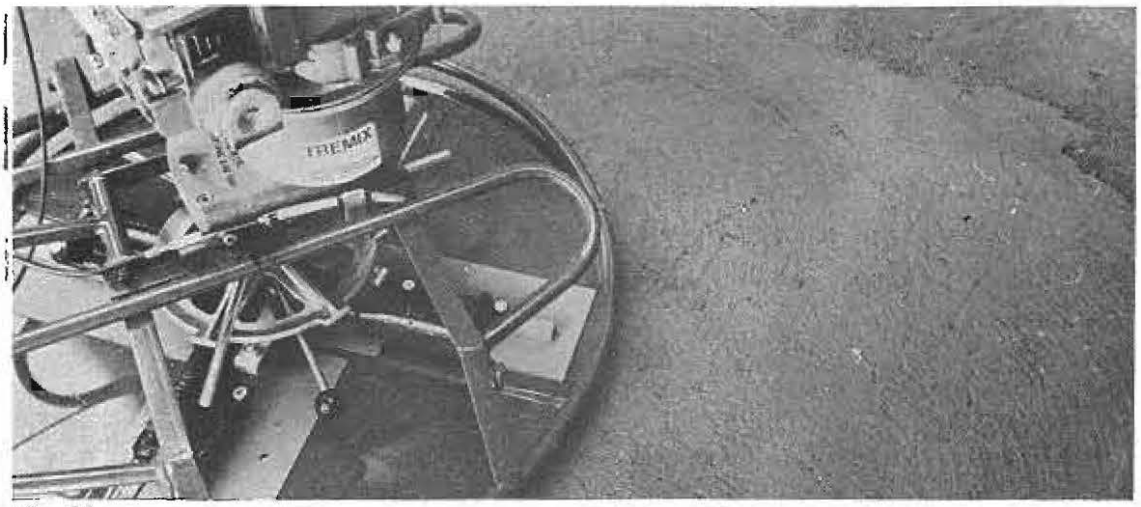


Fig. 12
CLASS U2 FLOATED (POWER). NOTE: THE FINISH SHOWN IS PRODUCED BY A DETACHABLE STEEL REVOLVING DISC MOUNTED BELOW THE TROWEL BLADES

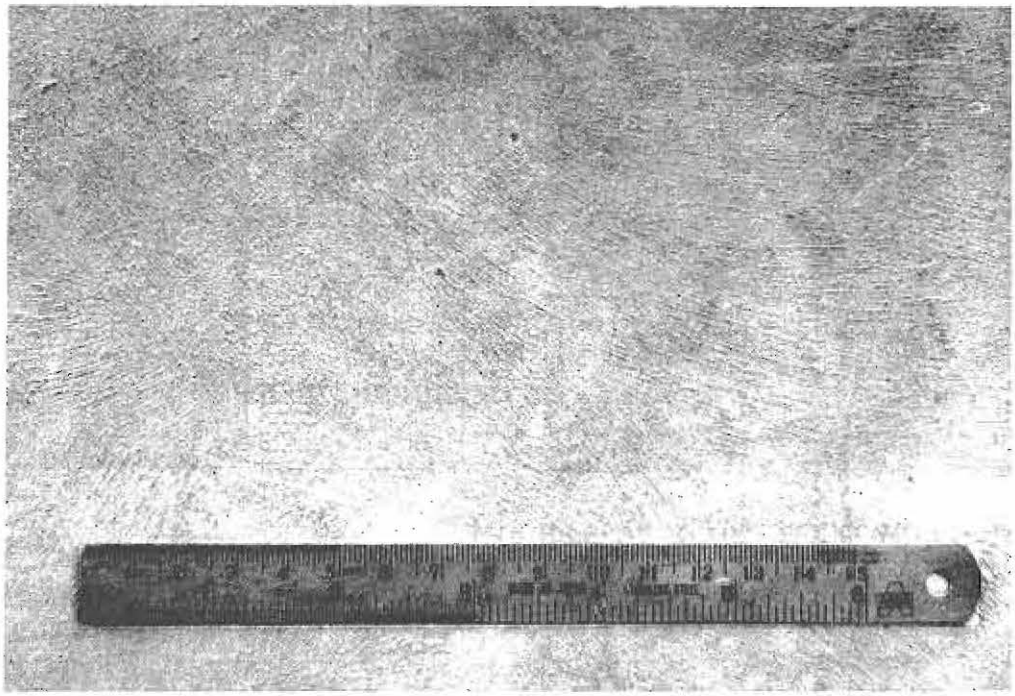


Fig. 13
CLASS U3, TROWELLED (FLOOR)

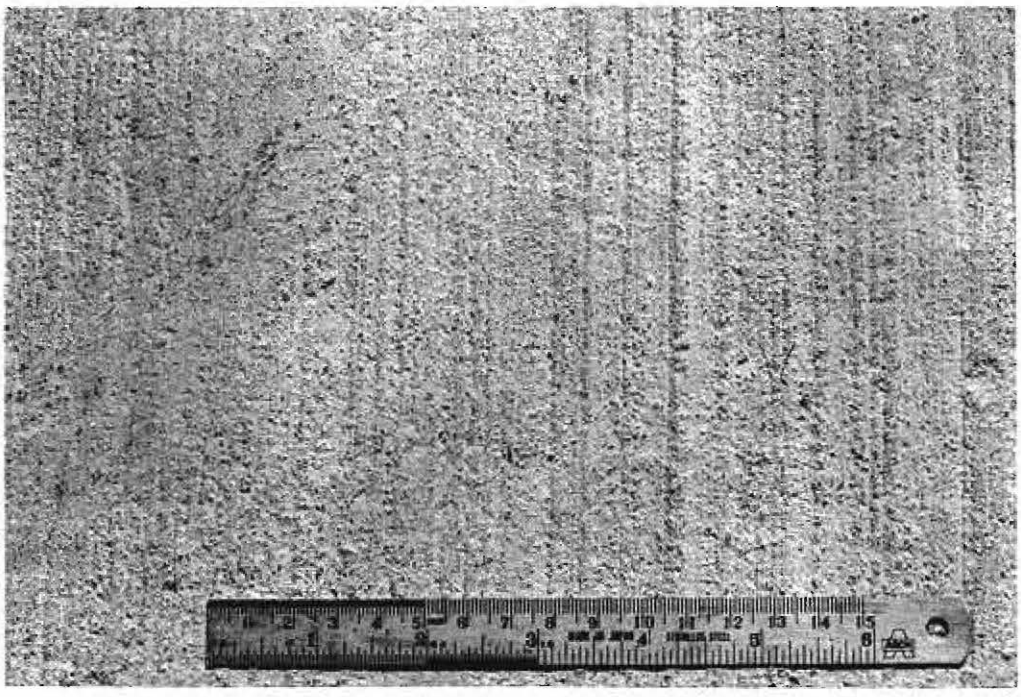


Fig. 14
CLASS U4, MACHINED (SPILLWAY)

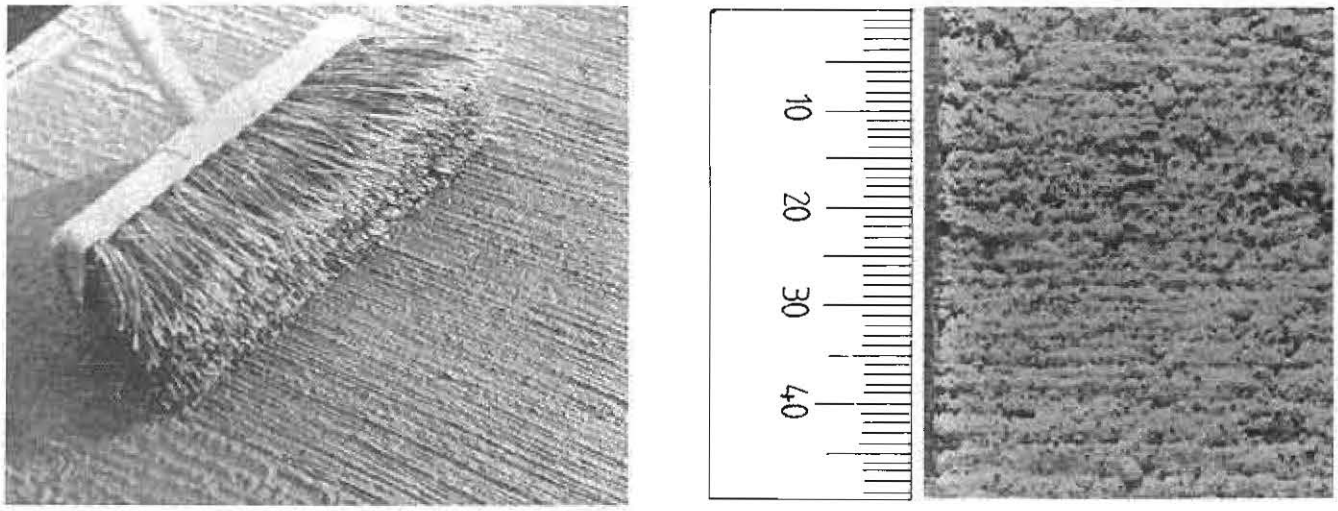


Fig. 15
CLASS U5, SHALLOW TEXTURED BY BASS BROOM

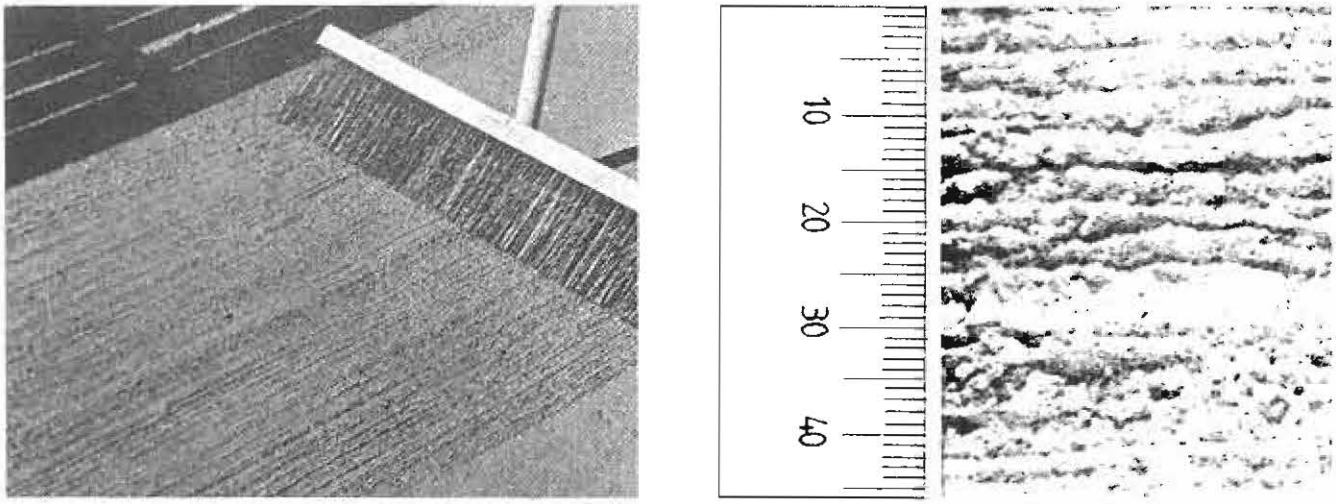
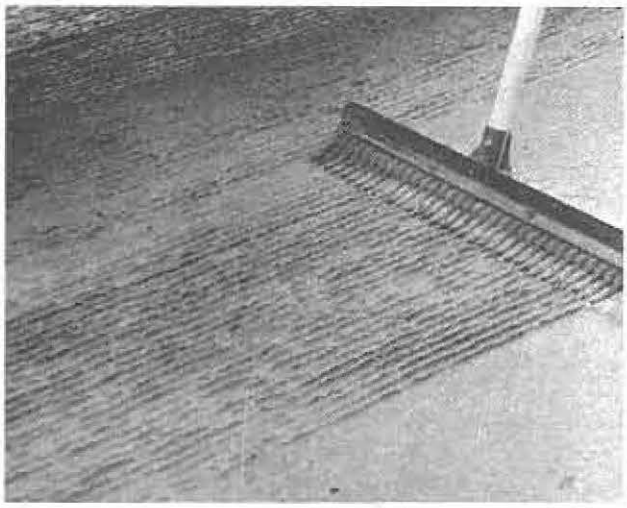
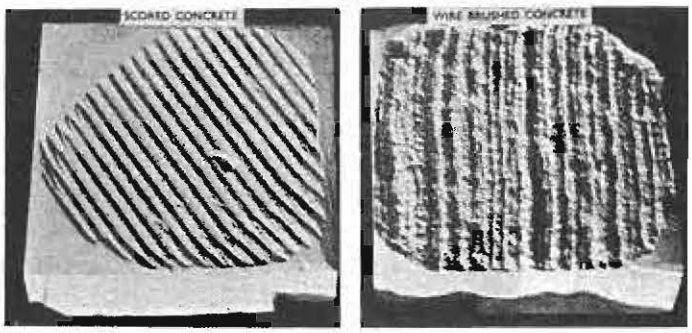


Fig. 16
CLASS U6, DEEP TEXTURED BY WIRE BROOM





Classes U6 and U7, plaster casts

Fig. 17
CLASS U6, DEEP TEXTURED BY RUBBER TYNED RAKE

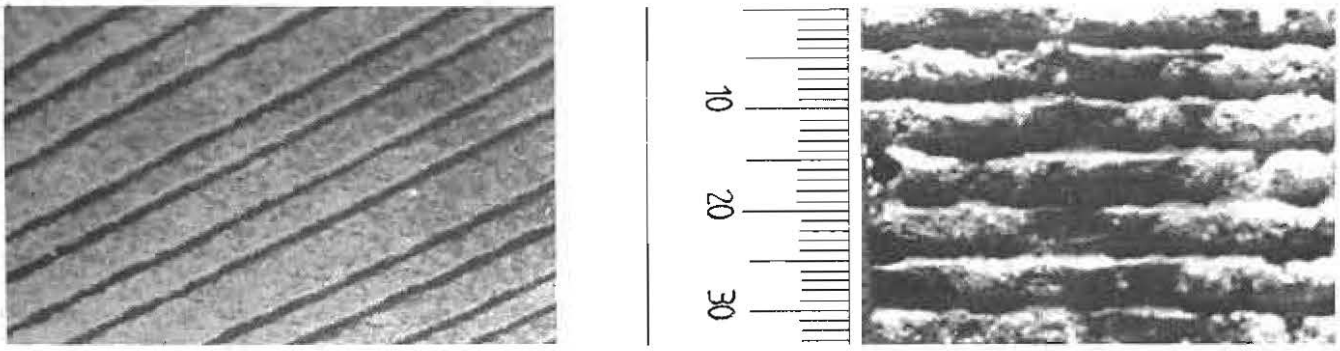


Fig. 18
CLASS U7, GROOVED BY FLAILING HARDENED CONCRETE

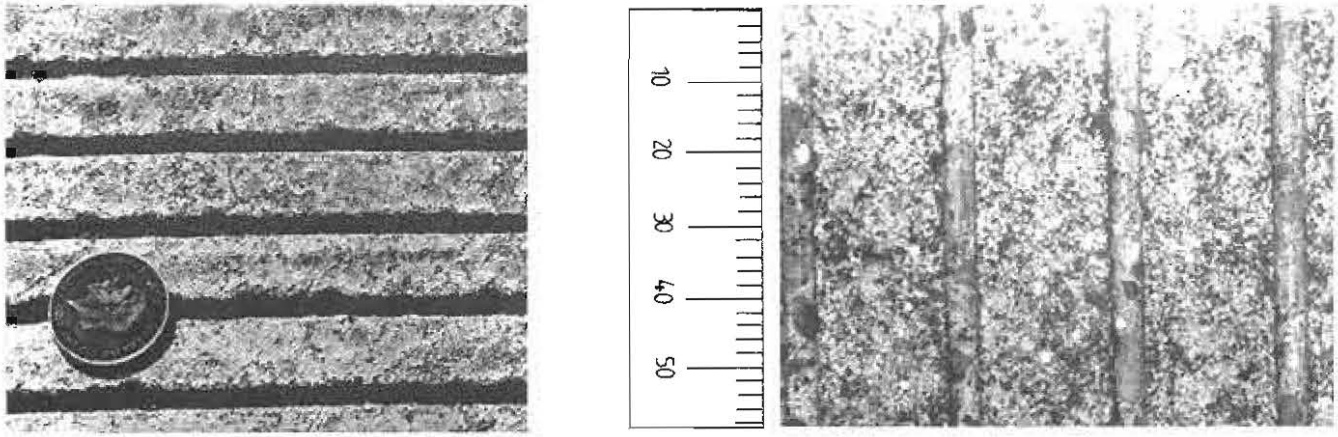


Fig. 19
CLASS U7, GROOVED BY SAWING

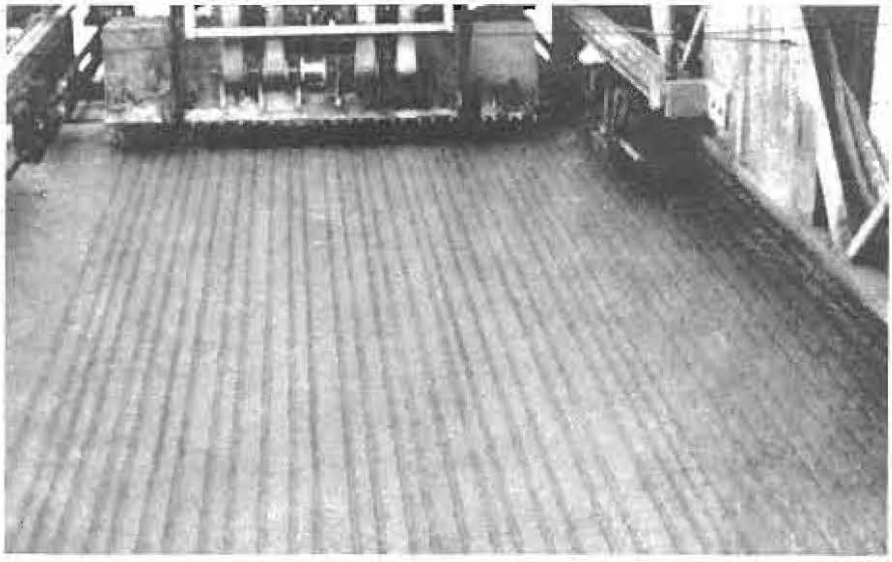
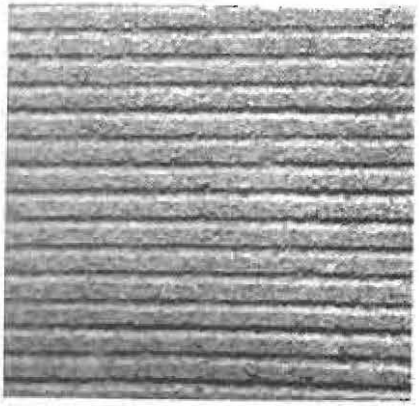


Fig. 20
CLASS U8, GROOVED FRESH CONCRETE

Fig. 21
CLASS U9, SCABBLED

Dragged (profiled board)



Rolled

Fig. 22
CLASS U10, SPECIAL TEXTURES

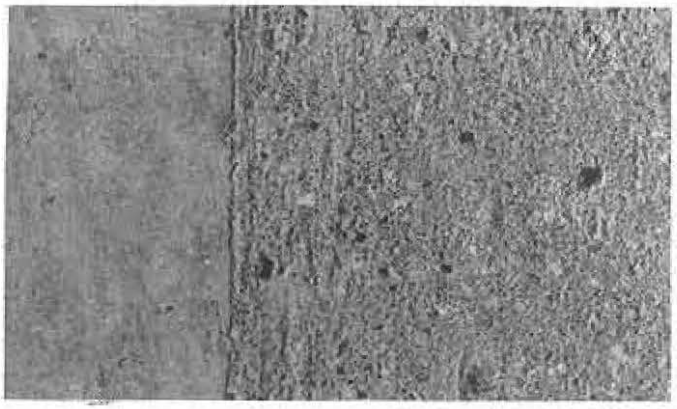


Fig. 23
CLASS U11, GROUND (RIGHT SIDE OF ILLUSTRATION)

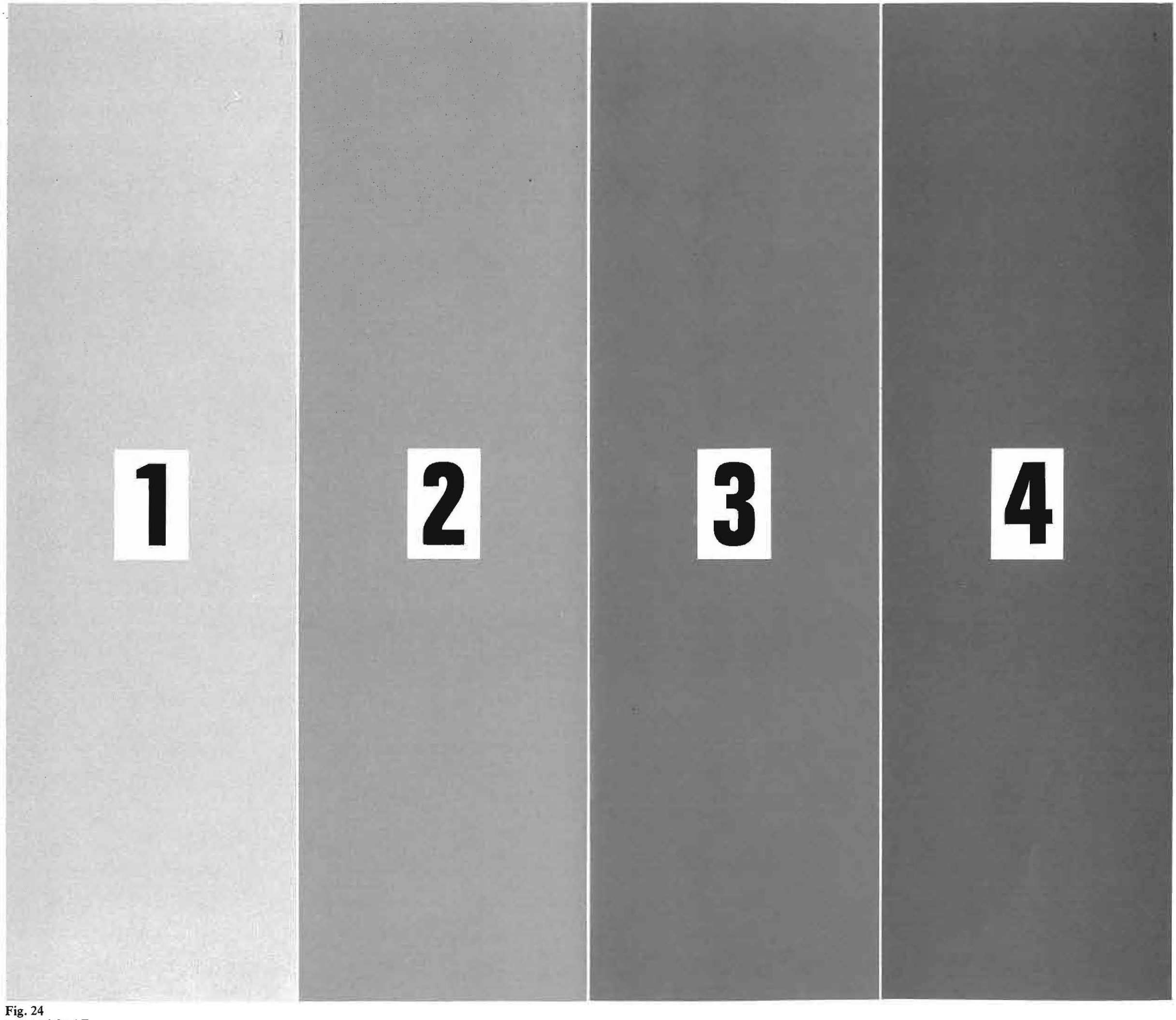


Fig. 24
GREY SCALE

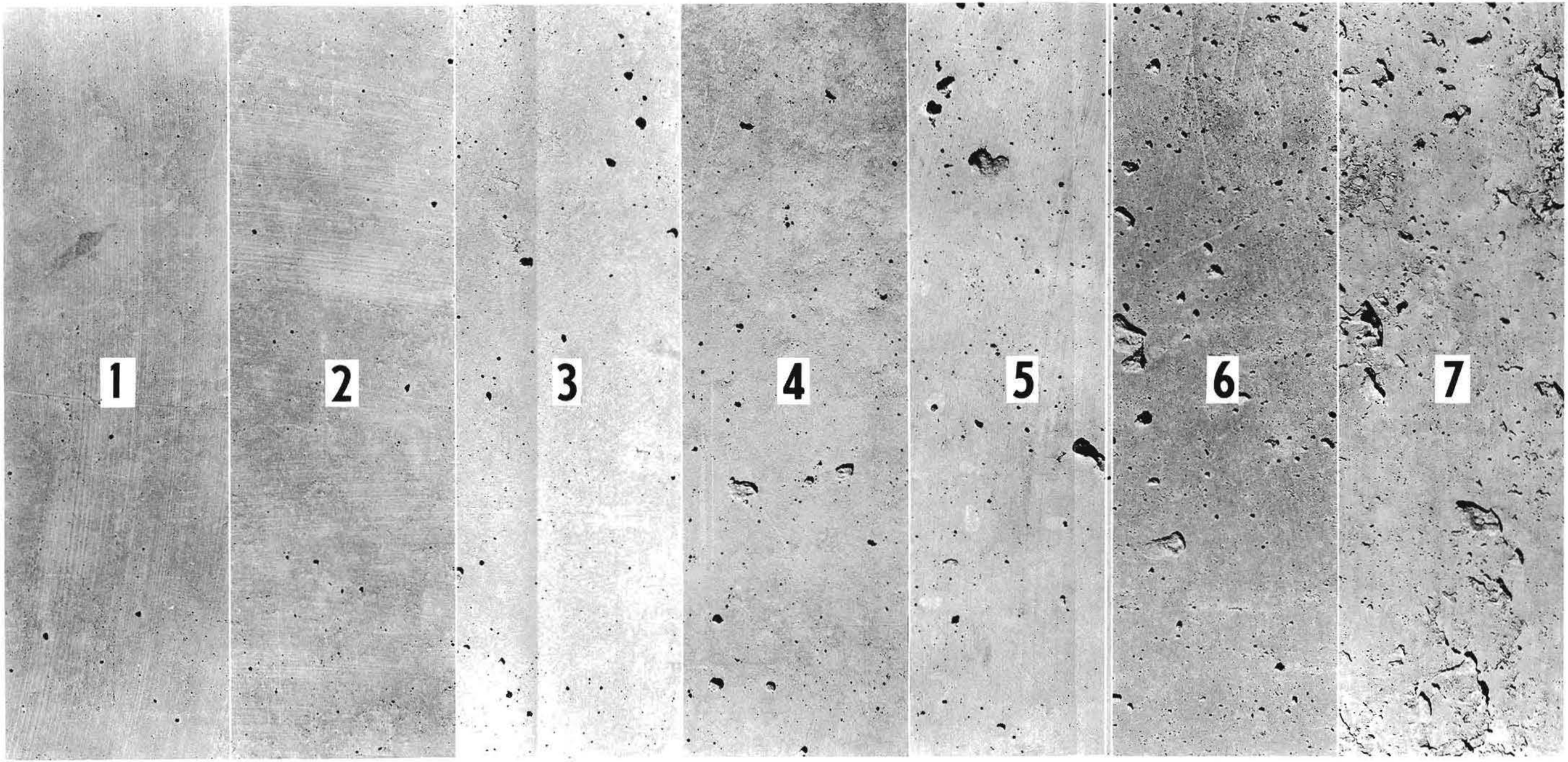


Fig. 25
BLOWHOLES

NOTES

NOTES

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