HIGHWAY RESEARCH
CIRCULAR

Number 53 Subject Areas: General Materials
Mineral Aggregates, Maintenance, General
October 1966

COMMITTEE ACTIVITY
in the
General Materials Division
Department of Materials and Construction
Highway Research Board

RESEARCH NEEDS

Research Problem Statements

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HIGHWAY RESEARCH BOARD
NATIONAL RESEARCH COUNCIL NATIONAL ACADEMY OF SCIENCES - NATIONAL ACADEMY OF ENGINEERING
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FOREWORD

Research proposals of the General Materials Division in the Materials and Construction Department cover a wide and diverse field.

In the area of aggregates, two of the proposals reflect the current concern over speed and accuracy of construction control. There is probably no question that in the hands of an experienced materials engineer the Sulfate Soundness Test results can be properly applied. However, its lack of reliability as a control test indicates further knowledge is needed. The proposed use of statistical specifications requires a new look at the sampling of aggregate since this procedure may have more effect on the spread of test results than has the material itself. As sources of good aggregate become depleted and long range planning of available sources become of importance, it is probable that knowledge of the effect of environment on the properties of in-place rock and gravel could be desirable. A Weather Severity Index may be useful to do this.

In the area of sealing joints in bridges and roadway pavements, it would seem that this apparently simple problem should be solved. Unfortunately, it is not. However, with the advent of new materials during the last two or three years, great strides have been made, and it now looks that if a concerted effort were made perhaps we could come to a reasonable solution. To do this, proposals have been made to study the adhesion and adhesives for joint seals, practical joint seal design methods, and more effective crack sealing in pavements.

In another area, that of highway culverts and conduits, the overall refinement of design of culvert pipes as well as the construction of higher fills has required the highway engineer to extrapolate experience and empirical formulas based on conditions that were far less demanding than at present. This has led to six proposals in this area covering non-symmetrical surface loads over buried flexible culverts, measurements of settlement ratios of buried rigid conduits, soil pressure on bored-into-place culverts, relative influence of yield point strength of material and stiffness of culvert walls in the support of soil pressure by buried flexible culverts, use of deformed mesh in reinforced concrete culvert pipe, and relationship between ultimate three-edged bearing loads and ultimate field loads for RC pipe.

As with the sealing of joints, the development of new materials for thin surface coatings has opened up a completely new area for worthwhile development. Most of such surfacings contain epoxy resins which have now been developed to the point where the highway engineer can use them economically. Five projects have been recommended in this area covering the following specific needs: Low or moderate cost, thin surface coatings; determination of effects of elements on epoxy resin compounds; epoxy resin-aggregate resurfacing; delamination of epoxy surfacings from concrete; and physical properties of epoxy resins.

In addition to the use of the epoxy resins in thin surface coatings, its use as an additive in concrete could produce a concrete with entirely new properties and design potential. To do so requires more knowledge so it is proposed to determine the basic properties of such a material.

Our committee on metals is especially active in the field of welding metallurgy. It is cognizant of the many new and exotic metals available today and also that the modern designer needs to depart from traditional proportions and details of design so as to realize the full benefits of modern technology. It is therefore recommended that the behavior of all forms of welded beams, girders and trusses under both static and fatigue loadings be explored in depth.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 1

Title:

Weather Severity Index.

The Problem Area:

Mineral Aggregates.

The Problem:

There is definite need for better characterization than now available of the environmental factors contributing to service performance of mineral aggregates in highway pavements and structures.

Objectives:

It is known that the moisture environment, and particularly the interplay of moisture content and freeze-thaw cycles in northern climates, importantly influence the behavior of mineral aggregates. These factors, and probably others which are at present poorly defined, sometimes combine to be highly destructive to the aggregates leading to premature distress of the construction. The primary aim of this research would be to first suitably identify the factors necessary for study which contribute to performance of mineral aggregates in highway pavements and structures and then develop a system to classify the environment, perhaps supplemented by a map or other means. Successful attack on this problem probably requires joint effort of the physicist to instrument in situ installations, the highway materials engineer, and the meteorologist.

References:

ASTM Standard Specifications for Building Brick, C62, includes a weathering index which depends upon the number of freezing cycle days and average winter rainfall. These values are plotted on a map of the United States. The Federal Housing Administration recently revised its concrete specifications for multi-family housing in which the cement factor and minimum compressive strength of the concrete depend upon the weathering exposure and type of structure. The ACI Recommended Practice for Selecting Proportions for Concrete (ACI 613-54) suggests values for maximum permissible water-cement ratio for different types of structures and degrees of exposure. Soils engineers have for many years considered use of a freezing index as related to depth of frost penetration (HRB Record No. 33, 1963). Tremper studied seasonal variations in interior moisture content of concrete pavement in California (HRB Bulletin No. 305, 1961).

Urgency:

If successful, this approach would be of great value to the researcher and highway engineer in developing and establishing the meaningful test methods and specification limits which are so urgently needed.

Research Problem Statement No. 2

Title:

Acceptance Sampling of Aggregate.

The Problem Area:

Mineral Aggregates.

The Problem:

There is need for development of a statistically sound acceptance sampling plan for aggregates to be used in highway construction.

Objectives:

Statistical specifications for construction materials are soon to become a reality. This infers that a statistically sound sampling plan is available on which to base such specifications. As an example, a stockpile of aggregate when taken as a whole can have only one gradation analysis. In order to develop a statistically sound randomized sampling plan, every portion of the pile must be available for sampling. Observed sample to sample variation of tests from this stockpile may well reflect segregation of the pile rather than off specification production. Both producer and consumer need legally defensible guides as to suitable procedures for sampling mineral aggregates to protect each party under rigidly applied specifications. This may require re-defining not only the mode of sampling, but the points in the production line where samples may be properly taken.

References:

ASTM D75 "Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials".

NCHRP Report No. 5, "Effects of Different Methods of Stockpiling Aggregates-Interim Report".

"Acceptance Sampling of Aggregate", J.E. Stephens (Presented at NCSA Meeting, Chicago, February 8, 1966.)

Urgency:

This matter of acceptance sampling of bulk materials is a subject of increasing concern and one which will be of utmost importance when statistical specifications become a reality.

Research Problem Statement No. 3

Title:

Sulfate Soundness Test.

The Problem Area:

Mineral Aggregates.

The Problem:

It has been indicated by research and generally accepted by highway materials engineers that the accelerated sulfate soundness test does not give reliable indications of the durability of an aggregate that may be subjected to the action of freezing and thawing. The proper evaluation of the soundness of aggregate for any part of the highway structure is needed. The highway materials engineer requests that he have a single test that is capable of evaluating an aggregate for bases, bituminous mixtures, and portland cement concrete.

Objectives:

To develop a test with more reliability than the sulfate test and requiring no more time to perform or preferably less.

References:

Efforts at developing a better test are exemplified by the California Durability Index (Hveem and Smith, HRB Record 62), and by the Iowa Water-Alcohol Test (Brink, HRB Bulletin 201).

Urgency:

This is a problem of long standing. The sulfate test is inadequate and is reported even to be theoretically untenable.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 4

Title:

Adhesion and Adhesives for Joint Seals.

The Problem Area:

Joints and Cracks in Structures and Pavements.

The Problem:

One overwhelming frequent type of failure of poured-in-place joint seals has been adhesion. Recent development of premolded compression seals have diminished this problem; however, it may be useful also here to provide adherence to the slab interface to better anchor the seal in the joint so that it cannot work up and out of the gap.

Objectives:

Basic study of the portland cement concrete interface, its physical and chemical characteristics.

Study of methods of preparing ths joint wall to receive the sealant.

Study of adhesive and/or primers to promote better bond between the sealant and the concrete.

References:

This is a rather fundamental study and therefore references would have to be collected from publications on adhesives. Some help can be obtained from HRB Committee MC-D3, "Sealants and Fillers for Joints and Cracks in Pavements".

Urgency:

This problem has high priority.

Research Problem Statement No. 5

Title:

Practical Joint Seal Design Method.

The Problem Area:

Joints and Cracks in Structures and Pavements.

The Problem:

During the last 12 years a considerable amount of numerical data has been developed providing the possibility of a more rational approach to joint seal design and joint sealing. Although much still remains to be done, we shall take stock of the present knowledge and come up with a suggested design guide for joint seals, which would be of practical use to state highway departments.

Objectives:

Define the most obvious and important factors affecting joint seal performance in numerical fashion, preferably in a graphical chart form which can be easily used by field engineers.

Define what properties of seal materials, or what kind of sealants best serve the above requirements.

Define the procedures necessary during installation of a selected sealant.

References:

Recent publications by John P. Cook, Raymond J. Schutz, Donald R. Dreher, Stewart C. Watson, Malcolm Graham, Egons Tons, and many others.

Urgency:

From a practical point of view, the most urgent problem concerning joints.

Research Problem Statement No. 6

Title:

More Effective Crack Sealing in Pavements.

The Problem Area:

Joints and Cracks in Structures and Pavements.

The Problem:

Cracks are often encountered in both portland cement and bituminous concrete surfaces. They allow penetration of water and solids which promote further deterioration of the cracked areas. Present methods of airblowing

and sealing, or simply pouring the crack full with a certain material often give only a short service life (probably less than a year). This is primarily due to (a) irregular width of the crack, not allowing a uniform sealing and getting a proper shape factor, and (b) inadequate or nonexistent adhesion between the sealant and the crack wall.

Objectives:

To determine the necessary preparation of the cracks to provide the proper geometric shape of the sealant and better adhesion.

To define the types of sealants (and maybe also primers) needed for effective crack sealing. Possibility of using two-phase sealants also should be considered.

References:

Some data has been published through the Joint Highway Research Project at MIT in connection with reflection cracking. Many states and the Military undoubtedly have data on crack sealing.

Urgency:

It is a problem which has been of concern for a long time.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 7

Title:

Measurements of Settlement Ratios of Buried Rigid Conduits in Field Installations.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

Present methods of predicting settlement ratios for conduits are reasonable but have not been substantiated by field checking.

Objectives:

The objectives of this research program would be to verify or modify if necessary the present theoretical methods for determining settlement ratios in the determination of loads on buried rigid conduits.

References:

Spangler, M.G., Soil Engineering, pp. 396-418. International 1960.

Urgency:

As methods for designing culverts become more accurate, the determination of accurate values for settlement ratios becomes increasingly important. Some field tests indicate that design engineers have been too conservative in the determination of settlement ratios. On the other hand, some few failures would indicate that a negative settlement ratio might have been the cause of failure.

Research Problem Statement No. 8

Title:

Relationship between Ultimate Three-edge Bearing Loads and Ultimate Field Loads for Reinforced Concrete Pipe.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

Field strength of reinforced concrete culvert pipe is determined from three-edge bearing test strengths by use of load factors. The use of the same load factor for both 0.01-inch crack and ultimate strengths gives erroneous results. This problem concerns the structural analysis of buried conduits and the interaction of the conduit with the surrounding soil.

Objectives:

To determine the correct ultimate load factors for reinforced concrete culvert pipe.

To ascertain correct factors of safety between working and ultimate field loads.

References:

M.G. Spangler, "Underground Conduits, an Appraisal of Modern Research", ASCE Trans. 1948, and

"A Preliminary Experiment in the Supporting Strength of Culvert Pipes in an Actual Embankment," Iowa State Bulletin No. 76.

W.R. Mason, "Strength of Large Concrete Pipe," Proc. 1948, Northwest Conference on Road Building.

Urgency:

Implicit in the use of load factors in design is the assumption that an equality of flexure stress exists between the test load and the field load. This assumption is substantially valid up to the point of 0.01-inch crack, but beyond this point secondary stresses leading to failure are produced. These latter stresses, resulting from pipe deformation, plastic yielding of the steel and concrete, diagonal tension and "slabbing", whether produced by field loading or test loading, cannot be related by the same load factor used within the elastic range. Knowledge of the proper ultimate load factor would result in more rational design procedures and a more reliable estimate of the factor of safety between working and failure loadings.

Research Problem Statement No. 9

Title:

Relative Influence of Yieldpoint Strength of Material and Stiffness of Culvert Walls in the Support of Soil Pressure by Buried Flexible Culverts Defined in Terms of Excessive Culvert Deformation and Soil Properties.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

The yieldpoint strength of the culvert wall is a critical factor in determining allowable soil pressures provided that the soil is dense and has a high friction angle. If the soil is highly compressible or viscous, the wall (i.e., ring) stiffness of the conduit may be the critical factor. For the range of soil types in between, there is an urgent need to know the relative influence of yieldpoint strength and the conduit wall stiffness on the allowable soil pressures at excessive deformation. The excessive deformation could either be excessive flattening of the culvert or could be a buckling due either to hydrostatic pressure or to ring compression.

Objectives:

Codes for culvert installations are beginning to appear. These codes generally favor the yieldpoint design method for ideal soil or the hydrostatic buckling design method for fluid soil but do not provide for the region in between wherein the soil properties may largely influence the structural performance of the culvert. The object of this research is to investigate this region.

References:

Meyerhof, G.G. and Baikie, L.D.,"Strength of Steel Culvert Sheets Bearing Against Compacted Sand Backfill," Highway Research Record, No. 30, publication 1130, pp. 1-13.

Urgency:

Before inadequate codes become standard procedure, the research must be completed.

Research Problem Statement No. 10

Title:

Nonsymmetrical Surface Loads over Buried Flexible Culverts.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

Most culverts are designed for a symmetrical soil pressure about (with respect to) the vertical axis or diameter of the culvert. If a high surface load is distributed only over one-half of the conduit cross section the loading situation is much more critical.

Objectives:

The objectives of this research project are to determine the effect on the buried culvert of a nonsymmetrical surface loading.

References:

Various Technical Bulletins of the U.S. Army Engineer Waterways Experiment Station.

Urgency:

Major conduit failures have been caused by nonsymmetrical surface loads over buried conduits. Minimum fill values must be determined as a function of factors such as soil properties and conduit strength and flexibility.

Research Problem Statement No. 11

Title:

Use of Deformed Mesh in Reinforced Concrete Culvert Pipe.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

Current specified steel requirements for various classes of reinforced concrete culvert pipe were derived from three-edge bearing tests on hot-rolled and cold-drawn steel rods as well as conventional fabric mesh. Steel manufacturers are now offering a cold-drawn deformed fabric which promises to improve cracking behavior of concrete pipe. Not enough test data presently exists to draw up comparable steel area requirements for all classes and diameters of concrete culvert pipe.

Objectives:

To produce a listing of minimum required deformed fabric steel areas for various diameters and classes of reinforced concrete culvert pipe.

References:

F. Heger, "Pilot Test Program for Evaluation of Fabri-Bond deformed cold-drawn Wire as Reinforcement in Precast Concrete Pipe", Report by Simpson, Gumpertz and Heger, Inc., 140 Mount Auburn Street, Cambridge, Massachusetts, November 1963.

Urgency:

Use of deformed fabric mesh would result in more economical reinforced concrete culvert pipe by allowing a reduction in steel area for a given strength requirement. Alternatively, by using presently specified areas, greater margins against cracking will be achieved.

Research Problem Statement No. 12

Title:

Soil Pressure on Bored-Into-Place Culverts.

The Problem Area:

Design and Construction of Culverts and Buried Conduits.

The Problem:

Anson Marston developed a theory for determining soil pressures on pipes in ditches or in soil fill. He did not include the analysis of soil pressures on pipes that are bored-into-place in existing soil. The case of the bored-into-place culvert should be analyzed and checked by means of model studies or field installations. This problem is basically in the area of culverts and culvert pipes but the theory may be considered also in the area of buried structures.

Objectives:

It is reasonable that the soil pressure on the bored-into-place pipe with the boring auger diameter slightly larger than the pipe will result in a reduced soil pressure against the pipe. The object of this needed research is to ascertain by theory and/or field and model studies the soil and hydrostatic pressures acting on a bored-into-place culvert as a function of factors such as pipe flexibility, ratio of diameters of auger to pipe, and soil properties. A secondary objective may involve the advisability of backfilling the area between the auger hole and the culvert.

References:

Spangler, M.G., Soil Engineering, pp. 396-418, International 1960.

Watkins, R.K. and Nielson, F.D., Development and Use of the Modpares Device, Journal of the Pipeline Division, Volume 90, Number PL1, January 1964, Proceedings, American Society of Civil Engineers.

Urgency:

The use of boring procedures for installation of culverts is increasing at a high rate. To the present time, these culverts are designed in the same manner as culverts in ditches or in fills. Such installation procedures probably result in considerable overdesign.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 13

Title:

Low or Moderate-Cost, Thin Surface Coatings.

The Problem Area:

Thin, Non-Bituminous Surface Coatings.

The Problem:

Much adverse criticism has been brought to bear on the thin-surface type protective coating or skid resistant overlay because of generally unsatisfactory performance and/or excessive cost. This is particularly true on bridge deck surfaces where the overlay is subjected to vibration, movement, extreme temperature ranges, and frequent freeze-thaw cycles.

Objectives:

Not only to continue explorations with epoxy resin adhesives, but to determine the effectiveness and evaluate the performance of other materials for this purpose, including polyurethanes, and neoprene and urethane-rubber polymers.

References:

Research work on these latter-type materials is apparently very limited.

Urgency:

The deterioration of bridge decks is reaching ever-increasing proportions. Corrective treatment is lagging because of a reluctance to use high-cost coatings and the inability to obtain generally acceptable and proven materials.

Research Problem Statement No. 14

Title:

Determination of the Effect of Elements on Epoxy Resin Compound.

The Problem Area:

Thin, Non-Bituminous Surface Coatings.

The Problem:

Epoxy resin compounds are rapidly becoming one of the most widely used construction adhesives and maintenance materials for use with concrete. The characteristics of these materials are so outstanding that this extensive use is being made without assurance that these materials have lasting qualities. Consequently, many job failures have been experienced. Determination of the effects of time, sunlight, heat, cold, freeze-thaw, and other "aging" parameters on epoxy resin compounds are needed.

Objectives:

To determine what factors and compound components effect the "aging" of these compounds. To establish suitable test methods for evaluating which epoxy compounds are free from adverse aging effects.

References:

Unreleased research work has been done in this area by the Ohio River Division of the U.S. Army Corps of Engineers. Other aging effects are described in reports available from the Engineering Research Laboratories of the University of Arizona.

Urgency:

The solution to the aging problems will immediately make possible a much broader use of the epoxy resin plastics in highway construction. It will lead to successful uses of these materials in all areas and conditions thereby reducing costly failures.

Research Problem Statement No. 15

Title:

Epoxy Resin Aggregate Resurfacing.

The Problem Area:

Thin, Non-Bituminous Surface Coatings.

The Problem:

There are many eroded portland cement concrete highway surfaces and bridge decks needing resurfacing with thin overlays of a permanent nature which will provide skidproofing and overcome the deleterious effects of freeze-thaw spalling. This problem, although largely confined to the States subject to freeze-thaw and the deleterious effects of de-icing salts, is more of nationwide scope if the repair of spalled expansion joints is considered.

Objectives:

To determine if polyester, epoxy resins or other resinous adhesives can be used as a binder in conjunction with suitable aggregate to economically restore eroded portland cement concrete highway surfaces and bridge decks by means of the application of overlays not exceeding 1/8-1/4 inch in thickness. At the present time a modified coal tar epoxy adhesive has been used for this type of work. However, other materials should be investigated which may have equal or better properties than the modified coal tar epoxies and which can be tinted gray to match the color of concrete.

References:

California in the Summer of 1964 resurfaced under contract 32 bridge decks in the high Sierras on Interstate 80 with an overlay of a gray pigmented epoxy aromatic petroleum oil epoxy system. The epoxy system was defined in terms of a Laboratory performance type specification. However, any work undertaken on this proposed research project should also include compositional as well as Laboratory performance type specifications.

Urgency:

Not stated.

Research Problem Statement No. 16

Title:

Delamination of Epoxy Surfacings from Concrete.

The Problem Area:

Thin, Non-Bituminous Surface Coatings.

The Problem:

Placement of sealants and overlays on portland cement concrete pavements and bridge decks to eliminate and minimize the distress in concrete resulting from the use of de-icing materials or from other causes has resulted in inadequate bonding.

Objectives:

To determine if the deficiency is resulting from such factor as: inadequate surface preparation; use of improper epoxy formulations; a needed change in size, gradation or shape of grit particles; improper application techniques; depth of aggregate embedment; or other factors.

References:

Information on research projects in this particular area is not available.

Urgency:

This problem has seriously curtailed a program for placement of epoxy bridge deck surfacing and an early solution of the program would enable this urgently needed repair work to be resumed. This information is also needed to aid in preparation of specifications, and is needed for new construction.

Research Problem Statement No. 17

Title:

Physical Properties of Epoxy Resins.

The Problem Area:

Thin, Non-Bituminous Surface Coatings.

The Problem:

Epoxy resin mortars are used presently to repair portland cement concrete pavements, curbs and structures. Both successes and failures of such repairs have been reported. It is believed by many that these failures are caused by using resin binders which are too brittle. There is not sufficient data available in this area to draw conclusions. Engineering properties are needed including thermal characteristics of the concrete and of the epoxy resin mortar.

Objectives:

The object of this research would be to find out the effect of modulus of elasticity or tensile elongation on the rate of failure of epoxy resin mortars applied to concrete. Research should also determine what modulus of elasticity or tensile elongation is required to ensure success.

Urgency:

The problem is urgent since many states are using these resinous mortars and the trend is for more and more highway departments to use these techniques. This research might result in the prevention of wasted effort and money.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 18

Title:

Epoxy Resin Admixture to Concrete.

The Problem Area:

Concrete Admixtures.

The Problem:

Concrete products are very weak in tension. While reinforced concrete members may be subjected to tensile forces, cracking of the concrete occurs. These cracks allow penetration of moisture, salts, and other foreign matter which initiates deterioration of concrete. An analysis of properties imparted to concrete by epoxy resins used as an admixture to a portland cement concrete mix is needed.

Objectives:

Studies have shown that concrete failure starts with the failure of bond between the aggregate and paste. The objective of this research would be to determine if an epoxy resin admixture could increase the bond between the aggregate and cement paste and if it could increase the strength of the paste. Useable tensile strengths in concrete mixes might thus be obtained. Likewise, increased compressive strengths may result.

References:

Research work of this type is unknown.

Urgency:

The deterioration of bridge decks is reaching ever increasing proportions. Successful admixtures to concrete might well lead to more maintenance free concrete.

Highway Research Board
Department of Materials and Construction
General Materials Division

Research Problem Statement No. 19

Title:

Behavior of Welded Beams, Girders and Trusses.

The Problem Area:

Bridge Design and Construction.

The Problem:

There is a need for more information developed by research into the behavior of welded beams, girders and trusses under both static and fatigue loadings, to enable Highway Bridge Engineers to prepare more efficient welded highway bridge designs.

Objectives:

To determine the behavior of welded beams, girders and tubular trusses of various proportions and details of design, under both static and fatigue loading.

References:

Under sponsorship of the Welding Research Council and the guidance of some of its advisory committees, a considerable amount of research work has been completed in this field and research studies are still under way. These studies and projects have already demonstrated the value of such research work in yielding information which leads to a much more efficient design of welded highway bridges and more intelligent inspection and supervision of construction work.

Urgency:

There is an urgent need for such information because nearly all of the State Highway Departments have been expanding their use of welded steel bridges recently. The questions which come into the Structural Welding Committee of the American Welding Society continually and in considerable volume reflect the need for such research information to provide the answers to these questions and to provide a basis for future additions and revisions in the specifications for welded highway and railway bridges which are prepared by the Structural Welding Committee of the American Welding Society, and which specifications have been widely adopted for bridge design and construction of welded bridges.

DEPARTMENT OF MATERIALS AND CONSTRUCTION *

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* Department, Division, and Committee Status prior to February 1, 1966 except:
Committee MC-D4, R.K. Watkins, Chairman to February 1, 1966
Committee MC-D6, LaMotte Grover, Chairman to February 1, 1966