# CHAPTER 7

# PAVEMENTS

# CONTENTS



# LIST OF TABLES

# CHAPTER 7

## PAVEMENTS

### 7–01 GENERAL

This chapter provides general guidance on the policies and procedures followed by the Department in the design of pavement structures, the provision of skid resistant pavement surfaces, and the selection of pavement types.

### 7–02 PAVEMENT TYPES

The two basic types of pavement structure are the rigid and the flexible. A rigid pavement structure consists of a portland cement concrete slab placed on a subbase course of granular material, normally crushed stone or gravel. The subbase course is often identified in the typical sections as a "base course" in line with the nomenclature used in the Puerto Rico standard specifications for crushed stone or gravel pavement courses. The subbase course may also consist of material stabilized by a suitable admixture such as lime or cement. When the roadbed soils are of subbase quality, the subbase may be omitted.

A flexible pavement structure consists of a surface course made of a mixture of mineral aggregates and bituminous materials placed on a base course and, if necessary, a subbase course. The base course immediately below the surface course consists of aggregates (crushed stone, gravel or crushed gravel) with or without admixtures. The subbase course, when used, normally consists of compacted layer of untreated gravel or material such as crushed stone, crushed gravel or gravel. When the required pavement structure is relatively thin the subbase course in often omitted.

Because of the advances achieved by the highway construction industry, practically all the surface courses for flexible pavement now being, used in Puerto Rico are made of hot bituminous mixes (asphalt concrete) produced under controlled plant conditions. Also, when a flexible pavement is selected for a high-volume major highway serving heavy truck traffic and requiring a relatively thick pavement structure, a bituminous hot plant mix is normally specified for the base course. Such a base course is commonly called "black base".

### 7–03 DESIGN OF PAVEMENT STRUCTURES

Guides for the structural design of both rigid and flexible pavement were developed some years back both by the Department of Public Works and the Highway Authority. These guides need to be reviewed and updated and until this work is completed, the 1972 AASHTO "Interim Guide for Design of Pavement Structures" is to be used as the Department's guide for the design of both rigid and flexible pavements, supplemented by the previous Highway Authority guides and the instructions included in this chapter.

### 7–03.01 GENERAL FACTORS

The following factors are related to the structural design of both rigid and flexible pavements.

1. TRAFFIC DATA—The traffic data needed for the pavement design is furnished by the Transportation Planning Area of the Department. It should include the current ADT, the ADT for the design year (design period is normally 20 years), the directional distribution factor "D", and the truck factor "T" (This factor should be the 24 hour truck factor and not the one normally associated with DHV used for geometric design purposes). In addition, the Transportation Planning Area provides the W-2 and W-4 tables from the most recent truck weights

survey. The W-2 tables show the classification of trucks by types at the weighing stations. The W-4 table includes the 18 — kip axle equivalency factors for both rigid and flexible pavements for the various truck types. These tables may be used to calculate the daily equivalent 18-kip single axle load applications for use with the design charts following the procedures detailed in the Highway Authority's structural design guides for flexible pavements (1970) and for concrete pavements (1968) (In the development of the 18K single axle equivalents for pavements designs, the ADT expected to use the facility upon opening it to traffic and the traffic projected 20 years hence, should be averaged). In these calculations, a 100% lane distribution factor should be used to determine the average number of 18-kip single axle load applications in the design lane when designing 2-lane highways and 80% when designing highways with two or more lanes in each direction.

2. SERVICEABILITY INDEX (Pt)—Design charts for two values of serviceability index, 2.0 and 2.5, are provided in the guide. A serviceability index of 2.5 should be used for all major highways, design classes RE—1 through R—6 and UE—1 through U—8. An index of 2.0 may be used for other roads and streets.

3. ROADBED SOILS—The performance of the pavement structure is directly related to the physical properties of the roadbed soils. The structural design guides are based on the premise that the roadbed soils will provide adequate support to obtain an economical pavement structure. The soils study should identify locations where special treatment or replacement of problem soils are expected such as those that are excessively expansive, resilient, or highly organic.

## 7—03.03 RIGID PAVEMENTS

The following conditions apply to the structural design of portland cement concrete (rigid) pavements.

1. MODULUS OF SUBGRADE REACTION (K)—The design chart for rigid pavements in the AASHTO guide requires the Westergaard's modulus of subgrade reaction (k) as a key factor in the use of the chart. The values of "k" for a specific highway section are to be furnished by the Soils and Materials Testing and Research Office of the Department. The values of "k" may be obtained by correlation with standard AASHTO test such as T—222 (ASTM D—1196), T—190 (ASTM D—2844) or T—193.

2. WORKING STRESS IN CONCRETE (ft)—The AASHTO design chart calls for the working stress in concrete (ft) as one of the controlling factors. The values shown on the chart are based on the flexural stress of concrete as obtained by AASHTO test T—97 (ASTM C—78), simple beam with thirs point loading. The current standard specifications of the Department for P.C. concrete pavement call for the concrete to have a splitting tensile strength of at least 480 psi at 28 days as determined by AASHTO T—198 (ASTM C—496). This is aproximately equivalent to a flexural strength of 700 psi. A working stress value of 525 psi (.75 x 700) should be used for the pavement design.

3. SUBBASE—A minimum subbase 15 cm thick of dense graded granular material shall be used under all PC concrete pavements except where subgrade soils are determined to be of subbase quality. When variations in the roadbed soils result in non-uniform support characteristics, variations may be required in the thickness of the subbase.

4. PAVEMENT THICKNESS—The minimum PC concrete pavement thickness to be used on major highways, design classes RE—1 through R—6 and UE—1 through U—8, shall be 20 cm even when a lower value is obtained from the design chart. The maximum thickness for the concrete pavement shall be 25 cm. Where the thickness obtained from the design chart exceeds

25 cm, the use of continuously reinforced concrete pavement may be considered and a new design analysis made on the basis of the alternate procedure given in Appendix D of the AASHTO guide.

5. IMPROVEMENT POLICIES—Pumping (Ejection of water and subgrade material through joints and cracks or at the pavement edge, caused by the deflection of the slab after free water has accumulated under the slab), excessive cracking, and faulting (failure of joints representing a nuisance to the driving public in that they may set up a resonance in the vehicle, which leads to rider discomfort) affect rigid pavements in Puerto Rico.

In order to improve in this areas the following policies are established:

a) Subgrades shall be stabilized wherever silt-clay materials of fair to poor rating as subgrade materials, are found.

b) Dowels for load transfer must be used if the joint spacing is greater than about 15 to 20 feet, to prevent faulting.

c) Transverse and longitudinal joints shall be sawed to a depth of T/3 by means of approved concrete saws.

The longitudinal joint shall be sawed before the end of the curing period but not latter than three (3) days after the pavement has been placed.

All joints shall be sawed before equipment or vehicles are allowed on the pavement.

The sawed area shall be thoroughly cleaned and, if required, the joint shall immediately be filled with sealer.

d) Underdrains—It is desirable to make certain that all surface infiltration is minimized.

Benefits derived from proper drainage cannot be overemphasized.

If the base is a drainable material, use of subdrains is to be recommended.

## 7—03.03 FLEXIBLE PAVEMENTS

The following conditions apply to the design of flexible pavements.

1. SOIL SUPPORT VALUE (S)—The design charts for flexible pavements in the AASHTO guide require a determination of the soil support value of the roadbed soil. This soil support value has no direct relationship to any procedure for testing soils. The soil support value for a specific highway section is to be furnished by the Soils and Materials Testing and Research Office of the Department. Approximate correlations values with Resistance R—values obtained by AASTO T—190 and with CBR values established by AASHTO T—193 are given in the Highway Authority's and DPW design guides respectively.

2. REGIONAL FACTOR (R)—The regional factor is used in the design chart to adjust the pavement structural number (SN) for various climatic conditions. The main variable in climatic conditions considered for this purpose in Puerto Rico has been the mean annual rainfall. The values developed for the Highway Authority's design guides are being currently used. These are as follows:

| Average Annual Precipitation | Regional Factor |
|---|---|
| 40" or less | 1.0 |
| 41 to 60" | 1.5 |
| 61 to 70" | 2.0 |

| | |
|---|---|
| 71 to 85" | 2.5 |
| 86 to 100" | 3.0 |
| over 100" | 3.5 |

The above values are not to be considered absolute. Other environmental conditions and local factors may require consideration and the application of engineering judgement in the design of specific road sections such as susceptibility to flooding, groundwater table, steep grades and subsurface drainage.

## TABLE 7–1

### MINIMUM THICKNESS OF FLEXIBLE PAVEMENT COURSES

(Centimeters)

| HIGHWAY DESIGN CLASS: | RE-1, 2, 3, 4, R-5 UE-1, 2, 3, 4, 5 | RE-4, R-6 U-6, 7, 8, 9 | R-7, 8, 9 | R-10, 11 U-10 |
|---|---|---|---|---|
| SURFACE COURSE | | | | |
| Asph. Concrete | (1) 5.0 | (1) 5.0 | 2.5 | 2.5 |
| BASE COURSE | | | | |
| Asph. Concrete | 15.0 | 10.0 | 5.0 | 5.0 |
| Cr. Stone or Cr. Gravel | (2) | (2) | 10.0 | 10.0 |
| SUBBASE (3) | | | | |
| Cr. Stone or Cr. Gravel | 15.0 | 15.0 | 15.0 | 10.0 |
| Gravel | 15.0 | 15.0 | 15.0 | 15.0 |

Notes:

(1) Normally placed in two layers with the top layer (wearing course) designed for skid resistance. See Section 7–04.

(2) Not recommended for these highway design classes.

(3) May be omitted in full depth asphalt concrete pavements or when roadbed soils are of subbase quality.

3. STRUCTURAL NUMBER (SN)—The structural number obtained from the design chart is an abstract number expressing the structural strength of the flexible pavement required for a particular combination of soil support value, equivalent 18-kip axle loads, terminal serviceability index, and regional factors. It is converted to actual thickness of surfacing, base and subbase courses by means of layer coefficients representing the relative strength of the material to be used in each pavement course.

4. LAYER COEFFICIENT—The layer coefficient expresses the relationship between the structural number (SN) and thickness, and is a measure of the relative ability of a material to function as a structural component of the pavement. Layer coefficients for various types of pavement materials, based on the AASHTO guides, are includes in the Highway Authority's design guide. The suggested values are to be applied to the depth of each pavement course expressed in centimeters.

5. COURSE THICKNESSES—Once the structural pavement number for the total pavement structure has been determined from the chart, alternate pavement structures are designed, using appropriate materials and layer coefficients for the surface, base and subbase courses, and

following the procedures included in the AASHTO design guide. The alternate designs are compared on the basis of economics, availability of materials, and other pertinent considerations to arrive at an optimum design.

A flexible pavement consists of a two-course or three-course structure. The composition of the pavement structure must be such that the strength characteristics of the surface course material are higher than those of the base or subbase, and the strength of the base course material is higher than that of the subbase. This must be kept in mind in selecting the materials to be used in each pavement course.

Minimum thickness requirements for the various materials commonly used for surface, base and subbase courses have been established to avoid the development of impractical designs. The minimum thicknesses recommended for use are shown in Table 7—1. These are minimum values only are and not to be interpreted as typical designs. The thickness of each course is to be based on the structural design analysis for the specific highway.

## 7—04 SKID RESISTANCE

Increased emphasis is being placed in providing skid resistant surfaces on new and old pavements as a major measure for reducing accidents and improving highway safety. The required level of pavement skid resistance depends primarily on the traffic volume and speed, with additional consideration given to special locations such as steep grades, curves, intersecting an other site requiring extreme vehicle maneuvering.

Adequate pavement surface drainage is an essential element in decreasing the skidding potential. Special attention should be given to providing adequate surface drainage at sag vertical curves, horizontal curve areas and transition locations where water buildup and ponding may occur. The requirement for adequate skid resistance surfaces becomes more critical with increased wet pavement time and increased traffic volume.

The current practices of the Department to obtain skid resistance surfaces are described in this section. However, the designer should be cognizant that research and experimentation is still going on in this field and he should be alert to new developments reported in AASHTO, TRB and FHWA publications. The Department's Materials and Soil Testing and Research Office is also working with the Construction Area and with the local asphalt concrete industry in developing improved skid resistant asphalt surfaces.

### 7—04.01 P.C. CONCRETE PAVEMENTS

The current standard specification for PC concrete pavement (Spc. 501) calls for a final broom finish. This specification is in the process of being revised and updated. Until such time as the revised specification is issued, all projects calling for PC concrete pavement on high speed highways (design of speeds of 50 mph or higher) will include a special provision modifying Spec. 501 to provide a final finish using a steel tined comb or other approved device that will produce tranverse corrugations in the surface 2 to 4 mm in depth, 2 to 3 mm in width, and randomly spaced at not less than 12 nor more than 25 mm.

The optimum time for grooving depends on many variables including concrete materials and proportions, consistency, temperature, humidity and wind velocity. The correct timing is to be determined on the job as the paving progresses. If done too early, the striations may become partially filled with mortar. If done too late, the desired depth may not be obtainable.

### 7—04.02 ASPHALT CONCRETE PAVEMENTS

To obtain a durable high skid resistance surface an open graded surface or wearing course mix made with highly polish-resistant aggregates is recommended. The materials and Soils

Testing and Research Office has developed variations of the standard Mix II-c (Spec. 401) which have already been used with satisfactory results. These new mixes are to be used on all new high-speed highway designs for which an asphalt concrete pavement has been selected.

The depth of the open graded mix should be twice the maximum size aggregate. Additional thickness is not necessary. If trueing and leveling is necessary, it should be accomplished by a fine mix prior to the placement of the open graded mix. A desirable practice is to specify it as the top or wearing layer of a 5 cm surface course.

## 7—05 SHOULDER PAVEMENTS

Shoulder pavements are not required to have the same structural strength as the pavement of the travel lanes. However, they should be capable of supporting intermittent heavy loads.

When a subbase is used it shall extend the full width of the roadbed which includes the shoulders.

Shoulders adjacent to PC concrete pavement can be either P.C. concrete or asphaltic concrete.

An asphalt concrete surface course should be at least 5 cm in depth, and its use instead of a P.C. concrete one is a matter of economics. The top or wearing layer should be an open graded surface mix with good skid resistance characteristics and sufficiently coarse in appearance and quality to discourage its use as a travel lane. The base course may be a dense graded untreated aggregate such as crushed stone or crushed gravel.

When the travel lanes are provided with an asphalt concrete pavement, the same surface course thickness is provided on the paved shoulders. However, a coarser mix should be specified to provide some degree of contrast. The shoulder base course may be a dense graded untreated aggregate such as crushed stone or crushed gravel.

Specific features of P.C. concrete shoulders are:

a) Reduction of pavement deflection.

b) Reduction of subsequent distress. Concrete shoulders may be thinner than the pavement and they must be tied to the pavement slab.

## 7—06 PAVEMENT TYPE SELECTION

The Department has not developed a specific analysis procedure to follow in the selection between a rigid or a flexible pavement type for a specific highway section. However, a report documenting the justification for the pavement type selected is required for all major highway sections. The factors included in the section of "Paving type Determination and Documentation" in the AASHTO booklet "An Informational Guide on Project Procedure" (1960) are to be followed as a guide. Of the 15 items listed in the AASHTO guide, all those appropriate to the specific highway under study are to be considered.

The following factors shall also be considered in conjunction with the AASHTO guide.

1. The cost of the pavement shall be a prime consideration in the selection of the type to be used.

2. In the absence of reliable cost accounting data, the annual maintenance cost should be considered equal for both the rigid and flexible types.

3. The salvage value of the two types of pavement at the end of the design period are considered to be equal.

4. It is expected that the flexible pavement will require at least one resurfacing layer (estimate 2.5 cm) during the normal design period of 20 years.

5. The levels of service provided by the two types of pavements are considered to be equivalent at all times.

6. In areas where the soils studies indicate that the subsoil conditions are such that subsidence requiring resurfacing should be expected during the design period, the consideration of rigid pavements may be omitted. For example, at all locations where the use of sand drains and/or surcharge are recommended to stabilize the existing soils, only flexible pavement will be considered.

7. A single type of pavement should be maintained on a highway section between major termini provided soil conditions permit it and there are no radical variations in cost.

8. Flexible type pavements are normally used for highways of design classes R—7 through R—11 and U—9, 10. No pavement type selection justification is required for these except in specific cases where a rigid type is recommended.

## 7—07 GOVERNING FACTORS IN PAVEMENT TYPE DETERMINATION

1. Traffic
2. Soils characteristics
3. Weather
4. Performance of similar pavements in the area
5. Economics or cost comparison
6. Adjacent existing pavements
7. Stage construction
8. Depressed, surface, or elevated design
9. Highway system
10. Conservation of aggregates
11. Stimulation of competition
12. Construction considerations
13. Municipal preference and recognition of local industry
14. Traffic Safety
15. Availability of and adaptations of local materials or of local commercially produced paving mixes

### PRINCIPLE FACTORS

I. Traffic

The volume of passenger cars generally affects only the geometric or lane requirement. The percentage of commercial traffic and frequency of heavy load application generally has the major direct effect on the structural design of the pavement. Existing heavy-duty highways constitute sufficient evidence that both flexible and rigid pavement designs can meet requirements under given conditions.

If a cost comparison between competitive paving types is to be of value, it is imperative that the structural designs compared have equal capacity to carry loads. Since the matter is one of basic economics, the cost comparison must also include not only the cost of original construction, but that of needed periodic repairs and routine maintenance over the service life of the pavement, and an estimate as to what its probable useable salvage value will be at the end of that time.

It must be conceded that in these important areas, some assumption still must be made pending the results of current and further research developments not already available in guide form. When such assumptions are made, they must be made by the best qualified personnel available.

Present legal load limits are, to all intents and purposes, frozen by the Federal-Aid Highway Act of 1956, and will remain until certain studies are presented to the Congress for its consideration and further action.

Even accepting this restriction, it is reasonable and proper to make allowances in the structural designs of pavements for possible future modest legal load increases as well as the occassional overloads, whether moving by special permit or illegally, that are likely to use the pavement.

Currently, the AASHO Transport Committee is preparing new proposed vehicle weights and size regulations for consideration of the various States from data received fr m the AASHO Road Test and other appropriate sources. The Transport Committee assignment is to develop recommended size and weights to give an optimum balance between the best highway use and maximum highway life, for roads and bridges that can be furnished with the funds available for highway purposes.

In the projection of the density and weight of future traffic that will likely use the pavement during its lifetime, it is essential that not only normal increases be enticipated, but that consideration be given to the possibility of additional traffic being generated by potential industrial development or changes in land use for the area served.

The construction of a modern highway may also divert large amounts of heavy traffic, from other routes in the same broad traffic corridor, that should be considered by the designer.

II. Soils Characteristics

Of paramount importance is the ability of a native soil, which forms the subgrade for the pavement structure in cuts and on areas the inherent qualities of such native soils are far from uniform, and they are further subjected to variations by the influence of weather.

The characteristics of native soil not only directly affect the pavement structure design, but may, in certain cases, dictate the type of pavement economically justified for a given location.

The evaluation of the characteristics of soils is, axiomatically, a requirement for each individual pavement structure design.

III. Weather

Weather affects subgrade as well as pavement wearing course. The amount of rainfall, will seasonally influence the bearing capacity of subgrade materials. Moisture, will affect pavement wearing surfaces as to maintenance costs, etc.

In drawing upon performance record of pavements elsewhere, it is most important to take into consideration the conditions pertaining in the particular climatic belt.

IV. Performance of Similar pavements in the Area

To a large degree, the experience and judgment of the highway engineer is based on the performance of pavements in the immediate area of his jurisdiction. Past performance is a valuable guide, provided there is good correlation between conditions and service requirements between the reference pavements and the designs under study. This factor should not be allowed to develop into blind prejudice. Caution must be urged against reliance on short-term performance records, and on those long-term records of pavements which may have been subjected to much lighter loadings for a large portion of their present life. The need for periodic reanalysis is apparant.

V. Cost Comparison

In any cost comparison of paving types, the matter of availability of local or commercially produced materials, and the existence and proximity of manufacturing or processing plants will be of significant importance.

Unavoidably, there will be instances where the financial circumstances are such as to make first cost the dominant factor in paving type selection even though greater maintenance costs may be involved later. Where circumstances permit, a better and more realistic measure would be the cost on the basis of service life or service rendered by a pavement structure. Such cost computation should reflect original investment, anticipated life, maintenance expenditures, and salvage value.

Original cost can be fairly accurately estimated. Doubt as to validity arises in the case where on type of pavement has been given monopoly status by the long-term exclusion of a competitive type.

The highly desirable determination of cost on a service life basis is presently adversely affected by some incomplete areas in needed factual information. One such area is the life expectancy of different paving types, a second, the matter of maintenance costs, and a third, the salvage value of pavements.

With our present state of limited knowledge as to the effect of frequency of heavy load applications, it is difficult to conceive of anything but an empirical approach to the determination of life expectancy of a pavement. The Bureau of Public Roads report "Lives of Highway Surfaces-Half Century Trends" shows a difference in the probable life for rigid and flexible pavements. It is not known if these trends hold for the pavements currently being constructed for the modern heavier traffic loadings, such as will be involved for the National System of Interstate and Defense Highways. The experience of the individual states as to assignment of probable life expectancy of different paving types, under the pertaining conditions, must for the present be accepted.

Assigned maintenance costs will seriously affect the cost comparison. If these costs are to be considered wholly valid, they must be based-on accurately kept, long-term maintenance records reflecting an established maintenance standard adhered to in practice. Since traffic and structural standards in the past have been such variables, it is difficult to accurately evaluate maintenance costs. This has not been a derelication of the highway official.

It is urged that the individual states take the necessary steps to develop factual information from Interstate System of highways, which will be valuable in the years ahead. These highways are built to modern standards. Establishment of, and adherence to, a maintenance standard, supplemented by accurate cost recording, will produce for the future more reliable data on maintenance cost and life expectancy.

Salvage value to be ascribed to pavements is somewhat open to conjecture. As it were, a large proportion of highway reconstruction involves changes in alignment or gradient which negate the salvage value. Each project actually must be considered individually.

## SECONDARY FACTORS

### I. Adjacent Existing Pavements

Provided there is no radical change in conditions, the choice of paving type on a highway may be influenced by existing sections thereof which have given adequate service. This will result in a desirable continuity of pavement and consequent simplification of maintenance operations.

### II. Stage Construction

Where financial circumstances dictate stage construction of the type of pavement, where a thinner wearing course is later brought up to design requirements by an additional course or courses of wearing course material, flexible design becomes mandatory.

### III. Depressed, Surface, or Elevated Design

Depressed and surface design may involve a high water table which will influence the choice of paving type. Elevated design, as in the case of approaches to long bridges or viaducts with concrete decks, may influence the decision in favor of rigid pavement to preserve a desirable continuity of pavement surface. A depressed design, presenting some periodic possible drainage problems, may also indicate the use of one type of pavement over another.

### IV. Highway System

It is not considered good practice to let a system designation influence the choice of paving type. Merits of the individual case and economics should prevail.

### V. Conservation of Aggregates

This consideration may well have influence in choosing a paving type which will involve, in the total pavement structure, less of the scarce critical material than might be required by another type.

### VI. Stimulation of Competiton

It is desirable that monoply situations be avoided, and that improvement in products and methods be encouraged through continued and healthy competition among industries involved in the production of paving materials.

### VII. Construction Consideration

Such considerations as speed of construction, reduction of traffic maintenance during construction, ease of replacement, anticipated future widening, need for minimum of surface maintenance in highly congested locations, seasons of the year when construction must be accomplished, and perhaps others may have a strong influence on paving type selections in specific cases.

### VIII. Municipal Preference, Participating Local Government Preference and Recognition of Local Industry

While these considerations seem outside of the realm of the highway engineer, they cannot always be ignored by the highway administrator, especially if all other factors involved are indecisive as to the pavement type to select.

### IX. Traffic Safety

The particular characteristics of a wearing course surface, the need for delineation through pavement and shoulder contrast, reflectivity under highway lighting, and the maintenance of a non-skid surface as affected by the available materials may each influence the paving type selection in specific locations.

X. Availability of and Adaptation of Local Materials or of Local Commercially Produced Paving Mixes

The prevalence of adaptability of local materials may influence, or the availability of commercial produced mixes particularly on small projects, may influence the selection of pavement type.

Conclusion . . .

In the foregoing, there have been listed and discussed those factors and considerations which influence, to various degree, the determination of paving types. This has brought to the fore the need, in certain areas, for the development of basic information that is not available at present. It has also served to point out that, in general, conditions are so variable, and influences sufficiently different from locality to locality, to necessitate a study of individual projects in most instances.

The public, although a critical judge, cannot be expected to be aware of the variety of considerations which influence the decisions of a highway administrator.

Consequently, whatever factors control the selection of the pavement type should be made part of the project file and should carry the identity of the person or persons involved in the entire process of making recommendations and in making the final decisions. It is very important that the reasons for reaching the decision be fully documented in the project file.

The judgment of the decision may be disputed at some subsequent time, but if the reasons are fully outlined and documented, the matter becomes only a difference of opinion and the reasons or the person of persons, who are responsibile for the decision, are a matter of record for any future review or investigation.