CHAPTER 12. AIRPORT PAVING

62. GENERAL. Airport pavements are constructed to provide adequate support for the loads imposed by airplanes using the airport and to produce a smooth, all-weather surface, free from dust or other particles that may be blown or picked up by propeller wash. Some airports may not require paved operational areas. Conditions at the site may be adaptable for the development of a turf surface adequate for limited operations of small airplanes. It may be possible to construct an aggregate-turf surface by improving the stability of a soil with the addition of aggregate prior to development of the turf. In most areas, however, it is not possible to provide and maintain a stable turf surface because of adverse weather conditions or high-traffic density. Under these conditions, construction of an all-weather pavement is necessary.

a. Pavements for airplanes under 12,500 pounds gross weight normally consist of locally available material with a bituminous surface course. To produce such pavements the coordination of proper design, construction, and inspection is required to assure the best combination of available materials and a high standard of workmanship.

b. Pavement courses are described as follows:

(1) Surface courses include portland cement concrete, bituminous concrete, aggregate bituminous mixtures, or bituminous surface treatments.

(2) Base courses consist of a variety of different materials which generally fall into two main classes, treated and untreated. The untreated bases consist of stone, slag, caliche, gravel, limerock, shell, sand-clay, coral, or any one of a variety of other approved materials. The treated bases normally consist of a crushed or uncrushed aggregate that has been mixed with cement or bitumen.

(3) Subbase courses consist of a granular material or a stabilized soil.

63. STAGE CONSTRUCTION.

a. Pavements by their nature can be constructed in stages, which may be advantageous when development funds are limited. Sponsors and engineers should be cautioned that the desire to provide immediate high-quality paved surfaces such as portland cement, concrete, or a hot-mix asphalt should not be accomplished at the expense of efficient drainage, proper grading, and adequate subbase and base course construction. Inadequate provision or recognition of these items may cause the loss of costly surface areas through frost action, water damage, or erosion. On the other hand, a properly constructed and drained pavement base may serve the airport's immediate operational requirements and be adequately protected by a limited surfacing such as a surface treatment or a single bituminous and stone chip seal application.

b. It should also be recognized, when the thinner surfaces are utilized in stage construction, that constant surveillance and timely maintenance are required. Even so, this may be the most satisfactory approach to construction with limited funds.

64. <u>SOIL INVESTIGATION AND EVALUATION</u>. Accurate identification and evaluation of the pavement foundation soils are a basic consideration in the design of pavements. The classification of these soils is discussed in detail in AC 150/5320-6 However, aspects which are particularly important to the airport designer are highlighted in the text that follows.

a. Soil conditions and the availability of suitable construction materials are the most important items affecting construction costs of landing areas and pavements. Grading costs are directly related to the difficulty with which excavation can be accomplished and compaction obtained.

b. The subgrade soil carries the load imposed by aircraft utilizing the facility. The pavement serves to distribute this load to the subgrade over a greater area than that of the tire contact. Thicker pavements distribute the load over a greater subgrade area. Therefore, the more unstable the subgrade soil, the greater is the required area of load distribution and consequently the greater is the required thickness of pavement. The soils having the best engineering characteristics encountered in the grading and excavating operations should be used in the upper layers of the subgrade.

c. In this manner, utilization of satisfactory local material can reduce the cost of pavements. Quite often, however, the soils encountered at the site are unsuitable and will not carry the loads intended. In such cases, the physical properties of unsuitable soils may be changed by admixtures, such as cement, lime, etc., to produce the desired qualities or may be overcome by capping or topping with suitable, locally available, borrow material.

d. In addition to the relationship which soil conditions bear to grading and paving operations, they determine the necessity for underdrains and materially influence the amount of surface runoff. Thus, they have a consequent effect on the size and extent of other drainage, structures, and facilities. (See FAA publication AC 150/5320-5, Airport Drainage.)

e. The distribution and physical properties of the various soils encountered on the site should be investigated, and this information combined with data on topography and climatic records will provide material essential to airport development. An investigation of soil conditions at an airport site should include:

(1) soil borings to determine the arrangement of different layers of the soil profile with relation to the proposed subgrade elevation;

(2) sampling of the layers of soil, and testing of the samples to determine the physical properties of the various soil materials with respect to stability and subgrade support; and

(3) a survey to determine the availability of materials for use in construction of the subgrade and pavement.

65. <u>PAVEMENT THICKNESS</u>. The design of pavement thickness is discussed in detail in AC 150/5320-6.

66. <u>SOIL STABILIZATION</u>. Soil stabilization is the procedure whereby the properties of a soil are improved to the extent that it will meet the requirements for pavement bases or subbases. Stabilized soils are not intended to serve as a surface course and must be provided with a surface in order to resist the abrasive action of operating vehicles or airplanes. Stabilization should provide a foundation which will eliminate or reduce to an appreciable extent the detrimental effects of volume changes occurring in the soil due to temperature and moisture changes. Mechanical and chemical stabilization are the two general types currently employed.

a. Mechanical stabilization on airports follows standard practices developed over the years, and requirements regarding materials as well as construction methods are well established. Performance studies have shown that the success of a granular stabilized base course depends on the gradation of the mixture and the physical properties of the material.

b. Bituminous stabilization is the combining of bituminous material with soil, soil aggregate, or sand to produce the desired soil characteristics. Bituminous stabilizing agents include cutback asphalts, slow-curing asphalts or road oils, emulsified asphalts, and tars. Methods of construction vary with the type of equipment available but, regardless of the equipment, the different steps consist essentially of: soil preparation by scarifying and pulverizing, thorough and uniform mixing of the bituminous material with the soil, curing of the mixture to get rid of excess moisture and volatile constituents, and compaction to a predetermined density.

c. By the addition of portland cement in the correct quantity, many types of soils and materials such as shale, gravel, sand, screenings, slag, and mine tailings can be stabilized. Construction of soil-cement bases has been standardized to a large degree.

d. Lime, in small percentages, has been added to base course materials such as gravel, disintegrated granite, crusher-run stone containing appreciable amount of soil-type overburden, and caliche in order to reduce the plasticity index to meet specification requirements. Performance records of highway pavements indicate this reduction in plasticity index markedly improves the stability of the base course. Lime could also be used to stabilize a clay subgrade.

e. Other chemical stabilizers such as resins, plastics, and metallic salts have been used as a means of improving the stability of soils. These methods are in various stages of development, however, and more work is necessary to determine their effectiveness. None of these materials or processes have been developed to the stage where they can be used effectively in the construction of civil airports.

67. AGGREGATE-TURF. Aggregate-turf strips differ from the usual turf strip in that the stability of the soil has been increased by the addition of granular materials prior to establishment of the turf. The objective of this type of construction is to provide a landing area that will not soften appreciably during wet weather and yet will retain sufficient soil to promote the growing of turf. Such a strip is designed to serve airplanes having a gross weight not exceeding 12,500 pounds (5 700 kg), although, under certain conditions, airplanes considerably in excess of this weight may be accommodated. In general, the material used in the aggregate-turf combination consists of whatever is locally available to accomplish construction as economically as possible. A
* more detailed discussion is found in AC 150/5320-6. *

CHAPTER 13. OPERATION, MAINTENANCE, AND ADMINISTRATION

68. WHO WILL OPERATE THE AIRPORT?

a. The airport is the airways entrance to the community it serves. To function properly it should be attractively maintained and should offer prompt and efficient services to those who use it. The longest and safest runway in the world will not consistently attract trade and commerce unless adequate arrangements have been made to provide:

(1) Essential supporting services to visiting aircraft (fuel, loading facilities, storage, and minor flight line repair).

(2) Basic conveniences to those who fly (waiting rooms, rest rooms, ground transportation, snack or dining facilities, telephones, auto parking).

(3) Flight services to meet local demand (air taxi, charter flights, aircraft and parts sales, aircraft and engine repair, flight training, etc.).

These are proprietary functions and can best be performed by private enterprise.

b. At a publicly owned airport the responsibility for maintaining and operating the landing area and other common use facilities is a public rather than a proprietary function. The relationships established between the owning public agency and those private enterprises which may be authorized to offer commodities and services are very important and should be carefully considered. (Where Federal funds have been provided for airport development, the public agency will have become obligated by contract with the Federal Government to continuously observe certain terms and conditions in its administration of the airport.) The public owner should retain sufficient control of the airport to insure that it can continue to meet its operating responsibilities.

c. Where the level of activity (and associated revenues) justify it, the employment of a full-time professional airport manager is highly desirable. Such a manager should be a salaried employee of the public agency, should not have any personal interest in any of the proprietary activities conducted at the airport, and should be given the authority as well as the responsibility to direct the efficient operation and maintenance of all airport facilities.

d. At most of the smaller publicly owned utility airports it may not be feasible or practical to retain the full-time services of an airport manager. In such instances, it is highly important to assign responsibility for policy and administrative direction to a designated official of the public agency. Routine day-to-day supervision of airport operations may be delegated to one of the tenanted proprietary activities doing business at the airport. However, exercise extreme care to distinguish between the functions performed by the tenant in his capacity as an agent of the airport owner and those in the conduct of his own business. Failure to make this distinction is the cause of many problems in the administration of smaller airports. In considering any such arrangements, make the responsibility for day-to-day maintenance and the enforcement of local airport regulations the subject of a separate contract for a separate monetary consideration and completely divorce it from any lease or rental arrangement by which the tenant obtains the use of airport premises and operating privileges for his business.

e. In some instances, a community may find itself handicapped by limitations in its municipal charter insofar as efficient business management of a public airport is concerned. For example, the charter may require placing all revenues and expenditures into the general funds making it impossible to clearly identify the cumulative record of airport transactions; or the charter may not permit or recognize such items as depreciation or accrued charges, etc.; or the organizational structure of the community may impose salary limitations on the hiring of a competent professional airport manager. For these and other reasons, many communities have found it advantageous to establish an autonomous airport "Authority" fully empowered to administer the airport with a separate fund, to hire its own employees, and to contract with business enterprises to provide the needed proprietary services.

69. <u>WILL THE AIRPORT SHOW A PROFIT?</u>

a. There is no reason why a publicly owned utility airport cannot ultimately be self-supporting. Like any other enterprise, a new airport may take several years to develop the level of activity necessary to meet expenses. As pointed out in Chapter 1, however, the direct dollar return is not a true measure of the value of the airport to the community.

b. A public agency operating a public airport is entitled to seek some recovery of expense incurred in providing the basic public facilities such as the landing area, taxiways, parking areas, terminal building, etc. At larger airports it is fairly common practice to impose a direct "toll" or landing fee for use of the landing area, particularly by scheduled air carriers. At most utility airports, however, the administration and collection of such a direct user charge is not practical. Recovery of some part of the costs of the public landing area is sought through an indirect form of revenue based on a sliding scale formula which will yield a return that varies in approximate proportion to the amount of use derived from the public landing area. A good example of this type of revenue would be a fuel flowage charge on all gasoline delivered at the airport or a payment expressed as a percentage of the gross volume of business done by tenant firms which provide supporting services. The level of such a flowage charge or the amount of the percentage is a matter for negotiation. Since such a revenue is intended to recover a user charge for public facilities, it is in addition to any rental payment that might be negotiated for the use of specific premises to be exclusively occupied at the airport for the conduct of a proprietary business.

70. AIRPORT LEASES.

a. The arrangements between a public agency/airport owner and those private agencies seeking to offer commodities and services at the airport are usually expressed in a contract. Since most of these contracts involve the right to occupy and use designated premises, they will generally be in the form of a lease. As in any such agreement the rental payments, terms of occupancy, privileges granted, obligations assumed, and other considerations are a matter of bargaining and negotiation between the parties. There are, however, some general principles peculiar to the airport environment which should be given careful consideration.

b. If the prospective tenant contemplates a substantial capital investment in hangars, fuel storage equipment, machinery, and store fixtures, etc., he will seek a relatively long term lease in order to be able to amortize his investment. It is to the advantage of the airport owner to encourage such private development and to offer sufficient tenure to induce it. On the other hand, aviation is dynamic and most airports evolve and expand much faster than anticipated. Chapter 5 outlined certain planning considerations for acquiring airport land. If within the first few years following the acquisition or construction of an airport the needs of commercial tenants require the occupancy of all available building areas, the planning for land use must be considered deficient. Therefore, in leasing airport property to commercial tenants, it would be well to avoid leasing more area than is reasonably required Similarly the granting of options (to lease land not yet needed) may well turn out to be the most regretted concession made during the initial negotiations.

c. A commercial tenant when contemplating a substantial investment at an airport will naturally seek some form of protection from competition. The airport owner in fact may be under considerable pressure during the negotiations to lease airport premises under terms which guarantee an exclusive monopoly. If the airport is owned by a public agency, it should realize that any exclusive right to conduct an "aeronautical activity" will make the public agency ineligible for various forms of potential Federal assistance listed below. Federal law prohibits the grant of an exclusive right to conduct an aeronautical activity at any airport on which Federal funds have been expended. However, there are alternate legal means of giving adequate protection to a commercial aeronautical enterprise at a public airport. Advisory Circular 150/5190-1, Minimum Standards for Commercial Aeronautical Activities on Public Airports, describes in detail how an airport owner may, and should, enforce standards of quality and levels of service, including capital equipment. Such standards are very effective in excluding marginal or irresponsible competitive operations, and there should be no compelling reason to lease airport facilities on an exclusive basis. The legal prohibition against airport monopolies does not apply to nonaeronautical activities such as restaurants, taxicabs, limousines, etc.

d. In negotiating a lease of airport premises, it would seem desirable to keep in mind the nature of the rights and privileges to be conferred for the rentals or other consideration to be paid. Usually an aeronautical enterprise seeks:

(1) The lease of specified premises for as long a term as it can hope to get.

(2) The right to conduct at those premises a wide range of activities with as little restriction thereon as possible.

(3) The rights, for itself and its customers, to use in common with others the runways, taxiways, and other public facilities of the airport.

A good lease will reflect thoughtful consideration of each of these objectives. For example:

(1) The lease of land or specific premises will be for a term long enough to amortize the investment to which the tenant will be committed. It will be for a firm rental rate. It will clearly spell out the respective housekeeping and insurance responsibilities of each party. If renewal options are contemplated there may be provision for the airport owner to terminate the lease upon reimbursing the tenant for the unamortized value of installed improvements. Above all, it will be consistent with the master plan for phased airport development and land use.

(2) The agreement or lease will clearly identify what the tenant is permitted to do. This represents a franchise right to conduct a business of offering commodities and services to those attracted to the airport. It will cite the applicable standards, codes, or ordinances covering the exercise of the franchise.

(3) The right to use the landing area should be for a separate consideration or payment since the use made of the landing area will vary with traffic. If a landing fee or toll charge is contemplated for others, the lease should clearly indicate who may use the landing area by virtue of the tenant's payments. The payment by the tenant for use of the landing area by his aircarft and those of his customers should not be "frozen" for the duration of a long term lease to real property. Even a utility airport may someday be expanded to accept jet aircraft, and the airport owner should be free to adjust the user charge commensurate with the increased operating costs involved.

71. AIRPORT REGULATIONS. The owner of a public airport should promulgate its policies and rules regarding the use of airport facilities. This may be done by local ordinance or through the publication of airport regulations. Such regulations are needed for the safety and protection of the public and to insure efficient use of airport facilities.

a. Airport owners should develop regulations to promote safety on airports by implementing restrictions on the usage of airport facilities (e.g., runway, taxiway, apron, and other maneuvering surfaces; jet blast precautions; assignment of parking positions, tiedowns; procedures for cargo and fuel farm services). Proposed regulations on airport operations and changes involving traffic patterns should be coordinated with the appropriate FAA Regional Airports Division. It is further recommended that proposed airport owner regulations be discussed with the appropriate FAA Flight Standards District Office. It should be noted that regulations controlling the use of airspace or the operation of aircraft may not be issued by the airport owner. In addition, any restrictions that could affect access to the airport by aircraft must meet applicable legal tests concerning burden on air commerce, discrimination, and reasonableness. Such restrictions should be coordinated in advance with the appropriate FAA Regional Airports Division. It is particularly important that any proposed operational changes be compatible with other FAA-approved operational practices at the airport, including those approved under a Noise Compatibility Program pursuant to 14 CFR Part 150.

b. Other matters to be covered by regulations include fire safety precautions; limitations on storage and handling of fuels; and restrictions on paint spraying, arc welding, or other potentially hazardous operations. Some rules or restrictions may be needed to insure sanitary conditions and to control trash disposal. Establish adequate regulations for vehicular traffic and automobile parking. In addition, regulations to control the public and prevent people from venturing upon the aircraft operating areas may be necessary.

72. AIRPORT ACCOUNTS. Although the administration of a public airport is not exactly a proprietary function, it does offer facilities and services at a price. It is in the public interest to efficiently manage such properties, to control costs, to maximize use of assets, and to prudently plan for capital expansion and further development. This requires a carefully designed system for fiscal accounting, preferably a separate airport fund apart from the general fund which finances other activities of the airport owner. If this is not possible, establish separate airport accounts within the general fund

a. Keep the fiscal data required for a small utility airport simple. The services of a professional accountant should be obtained in order to establish the record system,but the system itself should be simple enough to be maintained by available airport personnel. A Certified Public Accountant should audit the records at periodic intervals.

b. In designing an accounting system for an airport the accountant may suggest various alternate arrangements, and it is important that the airport owner give careful consideration to the basic needs for effective management of airport resources. For example, a record system may be suggested which will accumulate all maintenance and operating costs under groups or headings. These may be of various types:

(1) By object of expense (salaries, supplies, contracts, utilities, etc.), or

(2) By organizational responsibility (maintenance, fire protection, operations, etc.), or

(3) By types of facility (total cost per square yard for paving, cost per cubic foot to heat buildings, etc.), or

(4) By cost centers which are also centers of revenue recovery (terminal building, landing area, hangar area, etc.), or

(5) By a combination of the above.

c. Local conditions may dictate a preference for one of the above concepts in cost accounting. At most self-supporting airports the trend is toward the cost (and revenue) center concept exemplified by (4) above. In any event, the owner of a small utility airport should avoid the cumbersome and expensive bookkeeping system that would be required to account for each transaction in more than one of these ways. For instance, an expenditure of $100 to repair some paving should not have to be recorded as a paving expense and as a maintenance expense and as an expense of the landing area.

d. By using the cost center concept of fiscal control, as in paragraph 72b(4), the airport owner will be in a position to justify the proposed rental rates or landing fees. In addition, the airport owner will be better able to plan for future financing of needed capital facilities.

* 73. PROGRAMS FOR AIRPORT DEVELOPMENT, OPERATION, AND MAINTENANCE. Managers of publicly owned, public-use airports may find it beneficial to investigate the following programs.

a. Programs.

(1) The FAA, under the Airport and Airway Improvement Act of 1982, on a matching basis, provides support for the development of airport facilities deemed essential for a nationwide system of public airports.

(2) The Airport and Airway Improvement Act of 1982 also provides for the transfer of Federal lands under circumstances where it is necessary to carry out an airport development project or to operate a public airport. Information on this program is contained in FAR Part 154, Acquisition of U. S. Land for Public Airports.

(3) The Government Surplus Airports and Equipment Act, as amended (P.L. 80-289), authorizes the conveyance of surplus Federal property to public agencies under certain conditions when the FAA determines that the property is needed for public airport purposes.

(4) The Federal Property and Administrative Services Act continues, in effect, certain provisions of the foregoing legislation and authorizes the donation of surplus Federal equipment, or other personal property which may be useful in the development, operation, or maintenance of an airport, to the owners of public airports. Information on this program is found in AC 150/5150-2, Federal Surplus Personal Property for Public Airport Purposes, current edition.

b. Assistance. For information, advice, and assistance in taking advantage of any of these Federal programs, airport owners should contact an FAA regional Airports Division or an Airports District/Field Office (see AC 150/5000-3). In addition, a number of states have financial and/or administrative and engineering assistance programs. Details on these programs may be obtained through the state aeronautical agency. *

74. WHAT MAINTENANCE IS NECESSARY? Effective maintenance of airport facilities makes good business sense. It reduces the need for extensive repairs or replacement of facilities which have deteriorated. Some of the operations which are * considered vital to effective maintenance are discussed below. (A more detailed discussion is contained in AC 150/5380-6, Guidelines and Procedures for Maintenance of Airport Pavements, current edition.) *

a. A good turf will retard wind and water erosion of the land area. Ditch and embankment slopes are particularly vulnerable to erosion. Each gulley or channel created by erosion should be filled with suitable material and compacted as soon as discovered to reduce additional washing and to prevent the creation of a possible hazard to aircraft. Erosion control is especially important on a new airport until the fills have consolidated and the turf has become firmly established.

b. To maintain a good stand of grass, occasional application of fertilizer is necessary. Mowing is another essential operation in the maintenance of good turf. Frequency of mowing operations and the height to which the grass should be cut are largely determined by the growth characteristics of the grasses and the intended purpose of the turf. Under certain conditions, the use of chemicals may be necessary for weed eradication. Information regarding the chemical compounds available for this purpose, as well as those recommended for the control of insects and diseases, may be obtained from the local county agricultural agent.

* c. All paved or surfaced areas are to be inspected at regularly scheduled intervals, consistent with operational activity and local conditions, * including the condition of the runway and taxiway marking. Preventive maintenance actions which are important to long pavement life are pavement crack-sealing and seal-coating. The cost of these measures is minor and will generally preclude future major repairs of the pavement.

d. The field drainage system must be checked at frequent intervals and immediately corrected from any unsuitable conditions which may obstruct its proper functioning. Items which will need constant checking include: the plugging of inlet grates with grass cuttings, sticks, other debris, snow, and ice; the filling of the catch basins and pipes with sediment and waste; the settling and erosion around pipes and structures; and, the partial stoppage of ditches from sediment or vegetative growth.

e. The maintentenance needs of airport buildings are no different than other buildings. For example, buildings which are well protected by paint require less repair and look better those that are not. And in the case of an airport, the appearance of airport buildings helps determine the airports long-term success.

f. Removal of snow from an airport is more of an operational problem than a maintenance activity. Where snow removal is necessary, the use of plows or scrapers is satisfactory. However, building of windrows is poor practice since melting of the snow may saturate the pavement. Also, on other than paved surfaces care must be taken to avoid damaging the surface. On lighted airports exercise care to avoid hitting the runway edge lights.

g. Check the approach zones periodically for any new tree growth that requires trimming or removal. Airport lighting should receive regular maintenance by qualified electricians. For maintenance of * runway and taxiway lights, the procedure given in Advisory Circular 150/5340-24 should be followed. *

h. In general, maintenance is required regardless of use. Certain items may require less maintenance when operations are reduced, but the deterioration of most facilities is caused by the passage of time rather than activity.

75. WHO WILL PERFORM MAINTENANCE?

a. Airport maintenance work should be under the direct supervision of the airport manager. In the case of publicly owned airports, it may be handled economically by using the existing road, street, or park maintenance organization, which usually has on hand the necessary trained personnel and equipment. Where the services of such organizations are not available, the maintenance work can be handled by contract with a private concern.

b. In many cases, the necessary maintenance work will justify the purchase of maintenance equipment for use only at the airport. The purchase of a light truck, suitable mowing equipment, a roller, and handtools will normally be adequate to handle the major portion of the work of maintaining a small airport. In any event, the airport manager should have the authority to perform any necessary maintenance work on a regular continuing basis.

76. WHAT WILL MAINTENANCE COST?

a. The actual cost of maintenance will be extremely variable at different locations because of the fluctuation of any or all of the many individual maintenance items. Experience has shown that airports with turf landing strips can usually be maintained at much less expense than airports with paved runways. However, other factors fluctuate too widely to formulate any precise estimate. In general, however, it may be said that the annual cost of all airport maintenance will normally average between

1 1/2 and 3 1/2 percent of the total cost of constructing the airport (excluding land costs).

b. Airport maintenance can be held to a minimum if proper equipment and competent operating personnel are constantly available. Attend to items requiring correction as soon as the deficiency becomes apparent. Otherwise, the condition can become serious and repairs will prove costly. Small washes can soon become deep gullies, standing water can kill turf, and lack of timely mowing can cause turf to deteriorate. Giving immediate attention to such items will insure uninterrupted use of the airport. It is human to defer maintenance until the need for repair or even reconstruction is obvious, but the false economy of this procedure is apparent when the low cost of maintenance is weighed against the cost of reconstruction.

77. AIRPORT SAFETY. Every public airport, regardless of its size and activity, should have an effective safety program. Airport management should develop a continuing program to eliminate unsafe conditions and to provide immediate response to an emergency. The scope of the program is determined by airport needs and resources. Airports with low activity may find that strategic placement of fire extinguishers with simple operating instructions will satisfy their current on-site needs. However, every utility airport should have some type of aid agreement with local fire, police, and medical units. Also, there should be an agreement with a local firm for removal of disabled aircraft from the landing area. Practical measures must be taken in advance to meet anticipated emergencies and to maintain airport safety. All airports should have emergency telephone numbers posted in conspicuous locations.

78. AIRPORT BEAUTIFICATION. Beautification is not easily measured nor can its worth be calculated with any degree of accuracy. However, nature is beautiful and well-planned landscaping and buildings can be functional as well as aesthetically pleasing. The visitor's first impression of the airport is important to the community attempting to attract new industry. The condition of the airport is a good indicator of civic interest and support of community affairs.

a. Airport beautification projects have both aesthetic and functional benefits. Landscaping can prevent erosion and may help to attenuate aircraft noise on the airport. A well-planned land management program can reduce building and ground maintenance costs.

b. The best airport layout and engineering projects are not apparent to the public, but good landscaping, architecture, and overall cleanliness are apparent. It would, therefore, be in the best interests of the local airport sponsor to consider beautification as part of his maintenance program. The airport can also be a source of recreation for both aviation and nonaviation segments of the community. Recreation facilities and "airplane watching" are popular at many airport locations. Beautification projects can be effective in the cultivation of this interest and can do much to promote airports as a valued community asset.

c. Beautification is generally the outgrowth of good planning and land management. To be effective, begin airport beautification with a plan of what is to be done and how it is to be accomplished. Preferably, the plan should be the extension of a community's overall beautification program or part of a community's comprehensive land use plan. A planned beautification program is recommended, but it should not preclude independent airport beautification efforts provided they are well organized, accomplished with adequate professional guidance, and in scale with the airport. In preparing an airport beautification program consideration should be given, but not limited to, landspacing, architecture, and clearing programs.

79. LANDSCAPING. Choose trees, shrubbery, and ground cover that are well suited for local soil conditions and climate and that require a minimum of care. Keep the planting of annuals to a minimum. Avoid plants and ground cover which are especially attractive to birds.

a. Landscaping techniques can be effective to screen unsightly areas. Use plants and fences to hide trash collection points, aircraft parts, and equipment storage areas. Plants and fences may also improve the appearance of parking lots and are useful in keeping airport visitors from dangerous areas.

b. Paving and the general improvement of airport access roads and parking lots can do much to improve the appearance of airports. At many locations where unpaved roads and parking areas are in poor condition the application of gravel or dirt fill may be all that is necessary to correct the situation. Fill, especially earth excavated from local construction projects, may often be obtained at little or no cost to the airport owner.

c. The development of unused or unkept land on or adjacent to the airport for visitor and recreational use can be a promotional and revenue-producing activity. Such development may include roadside parking areas for "airplane watchers," visitors' facilities at terminal or administration buildings, picnic areas, and sports facilities, if located clear of approach zones and runways.

d. The leasing of unused airport land for growing or crops or nursery products can improve the appearance of land about the airport and will also put the land to productive use. Exercise care in the selection of plants for this purpose to minimize the attraction of birds and animals and to prevent hazards to aircraft operations.

e. Other beautification features of airport landscaping may include the installation of underground wiring, improved lighting, well-defined pedestrian circulation, and signs.

80. ARCHITECTURE. Airport structures, especially terminal and administration buildings, are focal points of airport activity. These buildings identify the airport and are places where people experience the activities of the airport. The condition of airport buildings, therefore, is often used by the public as a measure in judging the condition of the entire airport. In the construction of airport buildings, it is often easy to erect attractive buildings as it is to build something offensive.

a. Restoration of old airport buildings, including painting and structural repairs, can improve the overall appearance of the airport and reduce maintenance costs. Excessive repairs, heat loss, insurance rates, and other utility costs can often be reduced with a preventive maintenance program and other building improvements.

b. Improved interiors of airport terminal and administration buildings will also add to the amenities expected in such places of public assembly. Clean furniture, restrooms, and other lounge facilities are basic to any local building improvement program.

81. CLEANUP PROGRAMS.

a. These programs require little advance preparation, are inexpensive, and, in some cases, provide the most immediate visual improvement. A simple program to remove junk, trash, and unsightly underbrush; to repair fences; and to paint may be the only beautification activity required at some airports.

b. The county agricultural agent is the local representative of the Extension Service of the State Land Grant College or University and the Federal Extension Service. As such, he has available the latest agricultural research results. He can provide current information on grass, shrub, and tree species; soil testing; fertilization and landscaping plus cultural practices. The county agent also has available the services of university staff specialists in horticulture, forestry, soils, landscaping, agronomy, and other disciplines that may be included in a comprehensive beautification program. Under certain conditions, local nurseries and the U.S. Forest Service may offer plants for local beautification projects.

* CHAPTER 14. AIRPORT LAYOUT PLANS

82. GENERAL.

a. Public Law 94-168, Metric Conversion Act of 1975, declares a national policy of coordinating the increasing use of the metric system in the United States. The metric system of measurement is interpreted to mean the International System of Units (SI) as established by the General Conference of Weights and Measures in 1960. The transition to the metric system is to be voluntary and evolutionary with industry setting the pace. This means that the airport authority has the option to design the airport in either the U.S. customary or SI units. In keeping with the spirit of this policy, it is the intent of this chapter to provide metric transition guidance to those architects, engineers, and planners whose responsibility is to develop airport layout plans.

b. All airport development carried out with Federal financial assistance must be done in accordance with an approved airport layout plan (ALP). By definition, an airport layout plan is a scale drawing of existing and proposed facilities which the owner deems are necessary for the operation and the development of the airport. In addition, "approved" means that each airport layout plan, and any change in it, is subject to FAA approval. There is no requirement for an ALP on airports that are not subject to Federal agreement. Experience has shown, however, that any airport will benefit from a carefully developed plan that reflects current FAA design standards and planning criteria. The importance of having a plan on file with the FAA cannot be overemphasized, especially when either a Notice of Proposed Construction or Alteration (see AC 70/7460-2) or a Notice of Landing Area Proposal (see AC 70-2) is being reviewed. See paragraph 16 for the relationship between airspace determinations and airport layout plans.

c. Chapter 7, Airport Layout Plan, of AC 150/5070-6, Airport Master Plans, current edition, contains background information on the approval and development of airport layout plans, as well as a detailed listing of the various components that constitute a well-appointed airport layout plan. Obviously, much of the material that is presented in chapter 7 is nondimensional in nature and applies to either system. There are some aspects, however, that are not equally applicable to U.S. customary and SI units. The following paragraphs will explain these differences. *

★ 83. METRIC CONVERSION. The intent of this paragraph is to discuss metric conversion and to present concepts that go beyond simple conversion or the mathematical manipulation of values.

a. State of the Art.

(1) At the present time much of the conversion practice as seen in trade literature is limited to a dual system with equivalent units being expressed in parentheses. Those firms that conduct foreign practice have developed an expertise in working in the metric system, as have an increasing number of architect/engineer (A/E) firms in domestic practice.

(2) Numerous conversion tables are available for simple conversion of values; however, in order to carry the transition to its logical conclusion, we must become acquainted with such subjects as SI style, usage, accuracy, and rounding techniques. For a more comprehensive discussion of the SI system, American Society for Testing and Materials, ASTM E380-76, METRIC PRACTICE GUIDE, and the METRIC MANUAL, U.S. Department of the Interior, Bureau of Reclamation, are recommended references for engineers.

(3) Airport layout plans as well as other drawings can be developed in three ways:

(a) SI units only.

(b) U.S. customary units only.

(c) A combination of both systems.

In some instances, two sets of drawings have been developed to fulfill various requirements of bidding and construction. This practice is of course duplication of effort, but it may be economically justified under some circumstances where it is necessary to work in a medium with which people are familiar. Dual units, or the practice of simple conversion, can be and are being accomplished on the same drawing; however, this practice leads to clutter, confusion, and errors and is discouraged. The dual use of units is disastrous where customary units are confused with SI units and vice versa. ★

* b. The Hard Conversion Concept. Hard conversion is the creation of a new dimension that is judged to be a preferred or rationalized SI value. This new dimension is a change in the item's properties and will eventually result in international standardization of products and dimensions. Hard conversion has met with resistance to change because of presumed economical impact associated with change in dimension and modification of equipment. The FAA recommends the use of the hard conversion concept to the maximum extent practicable where the airport authority has optioned to go metric.

c. The Exact Conversion Concept. Exact conversion as the name implies relates to a type of conversion that results in a high degree of precision that may usually be associated with legal, scientific, or statistical applications rather than in the development of an airport layout plan. Airport design requires exact conversion at all interfaces between items designed under different systems of units.

d. The Soft Conversion Concept. Soft conversion results in essentially rounding of the converted value to the nearest integer or sensible number. The item or construction remains unaltered because the conversion is really nothing more than an interim form of conversion, rather than the creation of a dimensionally new component. This type of conversion may be used when the metric standard is not available.

e. Rounding of Converted Value. The recommended approach to rationalized dimensions is the following:

DIMENSIONAL CLASSIFICATION

Order of pref.	Very small dimensions up to about 50 mm	Small dimensions up to about 300 mm	Medium dimensions up to about 6000 mm	Large dimensions site layouts roadworks	Other numerical values	
					Range 1 to 100	Range 100 to 1000
1st	10 mm	100 mm	600 mm	10 m	10	100
2nd	5 mm	50 mm	300 mm	5 m	5	50
3rd	2 mm	25 mm	100 mm	1 m	2	20
4th	1 mm	10 mm	50 mm	.5 m	1	10
5th		5 mm	25 mm	.1 m		
6th		2 mm	10 mm			
7th		1 mm				

These values should be applied to achieve a reasonable balance between the smallest percent error and the highest order of preference. *

* 84. TYPICAL AIRPORT LAYOUT PLAN.

a. Introduction. The typical airport layout plan, figure 14-1, depicting a general utility airport, is presented in SI units. The intent of figure 14-1 is to acquaint people with the "look and feel" of a metric airport layout plan.

b. Drawing Scales.

(1) Introduction. The drawing scale must be selected before starting any drawing. This selection is basically a matter of choice; however, one should choose a scale that is easy to work with and that will enable appropriate details to be shown conveniently. The following list is a suggested reference:

Type of map	U.S. customary system		Metric system	
	(Inches) (Feet)	Unit ratio	(cm) (m)	Unit ratio
Location	1 = 2,000	1:24,000	1 = 250	1:25,000
Vicinity	1 = 4,000	1:48,000	1 = 500	1:50,000
Airport layout plan	1 = 200 to 1 = 600	1:2,400 to 1:7,200	1 = 25 to 1 = 500	1:2,500 to 1:5,000

(2) Unit Ratios. Maps and plans are often expressed in a natural or representative fraction (RF) scale. This means that the scale is independent of a particular system and can be converted to a system that best suits the user. Therefore, this natural or RF scale, or the unit ratio concept as used in this chapter, is directly applicable to metric conversion because it provides a means of working forward and backward from the customary system to the metric system. The following list of unit ratios will be helpful in understanding and using this concept:

Architect's scale		Engineer's scale	
Customary (Inches) (Feet)	Unit ratio	Customary (Inches) (Feet)	Unit ratio
3 = 1	1:4	1 = 10	1:120
1 1/2 = 1	1:8	1 = 20	1:240
1 = 1	1:12	1 = 30	1:360
3/4 = 1	1:16	1 = 40	1:480
1/2 = 1	1:24	1 = 50	1:600
3/8 = 1	1:32	1 = 60	1:720
1/4 = 1	1:48		
3/16 = 1	1:64		
1/8 = 1	1:96		
3/32 = 1	1:128		

*

* (3) Metric Scale Rules. Some of the more basic commercially available metric scales are listed below. These scales vary in size, shape, and material so the user will have an ample opportunity to select a scale that best suits the requirements of the project.

Metric scale (cm) (m)	Unit ratio
1 = .01	1:1
1 = .20	1:20
1 = .25	1:25
1 = .33 1/3	1:33 1/3
1 = .40	1:40
1 = .50	1:50
1 = .75	1:75
1 = .80	1:80
1 = 1.00	1:100
1 = 1.25	1:125

It should be evident that various scales are available. Therefore, for convenience, we recommend the use of scales that are multiples and reciprocals of 1, 2, and 5, rather than some value that falls between these ratios.

c. Contours.

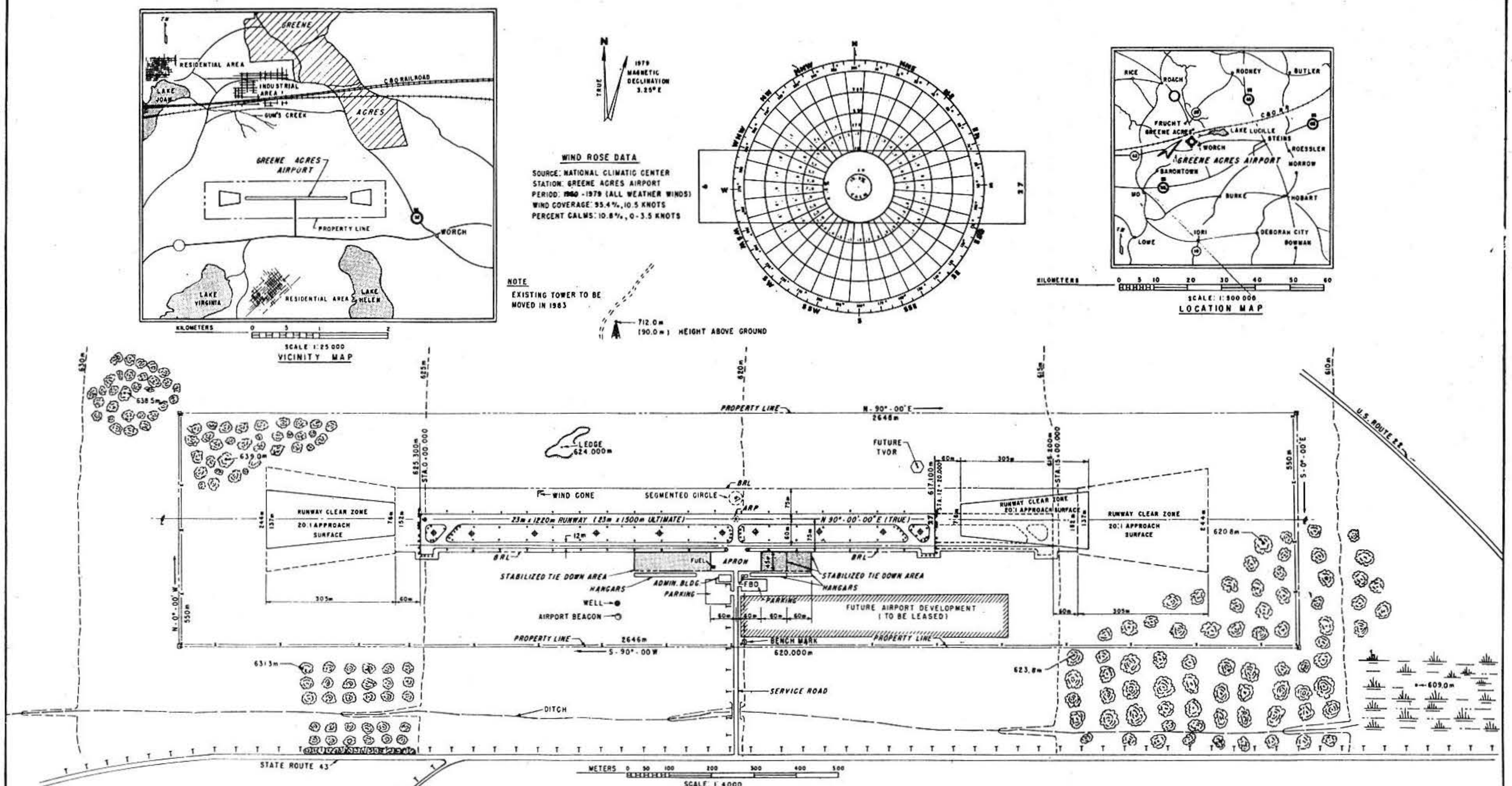
(1) One requirement of the airport layout plan is to give an indication of existing contours so that insight can be gained on how to develop the land and how the facility will relate to possible existing obstructions. Contour intervals should be chosen such that they adequately show the important features and changes in ground elevation. The contour lines should not be so numerous or pronounced that they clutter the drawing or overpower the other details.

(2) A topographic survey is one method of determining the existing elevations and physical features of an area to be developed. This survey can be run independently or in conjunction with a property line survey. Because of the transitional climate that exists at this time and because of the compatibility with available equipment and existing land records, land surveyors are still practicing in customary units. This does not mean that data taken in the customary system cannot be transformed and presented in metric units if required or requested. *

* (3) U.S. Geological Survey topographic maps show existing contours. All new U.S. Geological Survey topographic maps are being developed in the metric system, except in those states that have not been completed and have optioned for completing the balance of their contracts in the customary system. Puerto Rico is mapped in the 1:20,000 metric scale, 7.5 X 15 minute format. By and large, it is estimated that it may take as long as 50 years to map the United States in the 1:25,000 metric scale series. Therefore, in those localities where a metric topographical map exists, there will be no problem developing metric contours, but in those areas where a metric map does not exist, some form of conversion will be necessary to work from available 1:24,000-scale topographical maps.

(4) It is recommended that elevations be shown in meters, with the number of decimal places used to be a function of the precision required. For example, elevations for earthwork and excavations will be shown to two decimal places, while concrete and steel work will be shown to three places. *

FIGURE 14-1. AIRPORT LAYOUT PLAN



RUNWAY DATA TABLE		
ITEM	RUNWAY 9-27	
	EXISTING	ULTIMATE
AVERAGE RUNWAY GRADIENT (%)	0.67	0.67
WIND COVERAGE (%), 10.5 KNOTS	95.4	95.4
RUNWAY CATEGORY	U-V	U-NPI
PAVEMENT DESIGN STRENGTH (kg), GROSS	9100	9100
APPROACH SLOPES AND CLEAR ZONES	20:1	20:1
LIGHTING	R/W+T/W	SAME
MARKING	BASIC	SAME
VISUAL APPROACH AIDS	REIL	VASI & REIL

AIRPORT DATA TABLE		
ITEM	EXISTING	ULTIMATE
AIRPORT ELEVATION, METERS	625.300	SAME
AIRPORT REFERENCE POINT (ARP) LATITUDE	41°-50'-10"	
AIRPORT REFERENCE POINT (ARP) LONGITUDE	73°-13'-30"	
TAXIWAY MARKINGS	NONE	NONE
NAVIGATIONAL AIDS	NONE	TVOR
AIRPORT CATEGORY	G UTILITY	SAME
MEAN DAILY MAXIMUM TEMPERATURE °C	29.4	SAME

LEGEND		
EXISTING	ULTIMATE	ITEM
————		BUILDING RESTRICTION LINE (BRL)
--630--		GROUND CONTOURS
— — —		AIRPORT PROPERTY LINE
••• •••		THRESHOLD LIGHTS
———	- - - -	FACILITIES
x—x—x		FENCE
• • • •		RUNWAY LIGHTS
• • • •		TAXIWAY LIGHTS
(symbol)		TREES
T T T		TELEPHONE LINE
(symbol)		BOUNDARY MONUMENT
(symbol)		STORM WATER INLET
	(symbol)	TVOR
(symbol)		SUPPLEMENTAL WIND CONE

NOTE:

1. THIS PLAN SHOULD NOT BE USED AS A STANDARD FOR PLANNING OR DESIGN.

M METRIC	NO	REVISIONS	BY	APP. DATE
SUBMITTED BY: DATE: F.K. BIG ASSOCIATES CONSULTING ENGINEERS	RESID COUNTY AIRPORT COMMISSION			
APPROVAL BLOCK	GREENE ACRES AIRPORT ANYWHERE, U.S.A. AIRPORT LAYOUT PLAN			
	F.K. BIG ASSOCIATES CONSULTING ENGINEERS			
	DESIGNED BY: ___ DATE: ___ DRAWN BY: ___ DATE: ___	TRACED BY: ___ DATE: ___ CHECKED BY: ___ DATE: ___		
	DRAWING NO.	SCALE AS SHOWN SHEET 1 OF 1		

* CHAPTER 15. CONSTRUCTION PLANS *

85. GENERAL. The purpose of a set of plans is to show the location, character, dimensions, and details of the airport and the work to be done. Such plans enable competitive bidding and lead to achievement of economic construction while maintaining high standards. Accordingly, it is in the best interest of all parties involved in airport development to prepare a set of plans and specifications as part of the construction contract.

86. TYPICAL SET OF PLANS. A typical set of airport plans has been developed as a guide to the preparation of a complete and up-to-date set of plans for construction of utility airports. The typical set is included as appendix 4 to this circular and should be used in conjunction with the information provided herein. Furthermore, it is emphasized that the plans provide guidance only and are not to be copied for development of an airport component. Only qualified engineers should prepare the actual construction plans for an airport project.

a. The number of drawings and the extent of information needed for any specific development will vary depending on the scope and character of the project. Plans for expansion of facilities at an existing airport will usually require less engineering and fewer drawings than for the initial development of an airport.

b Technical standards which should be utilized in the preparation of construction plans are listed in Appendix 10, Bibliography. These standards form the basis of the typical set of plans. However, it is not intended that such standards be applied blindly. In certain circumstances, a deviation from a standard either to a lesser or to a greater degree may be warranted. Therefore, it is advisable to closely coordinate preparation of the project plans with FAA airport engineers. The locations of offices which can provide this service are listed in AC 150/5000-3.

c. An engineer's report should be an integral part of the data furnished for the project. This report should state the basis of the engineer's design. Subjects discussed should include drainage analysis, soil and subgrade determinations, recommended paving sections, turfing, all unusual features of the design, and any deviation from standards. The engineer's report need not be given to construction bidders.

d. The project layout plan has been included in the typical set of plans to obtain a complete picture of present and future development of the airport. However, it is strongly emphasized that the aiport layout plan must be formulated prior to any initiation of construction plans. Master planning cannot be effectively done concurrently with preparation of the project plans. (See AC 150/5070-6.)

e. Lighting plans are included in the typical set of plans for general guidance. However, the specialized nature of airport lighting requires particular attention to numerous details which cannot be adequately illustrated in the limited space available in the typical set. Chapter 11 discusses airfield lighting systems and other visual aids.

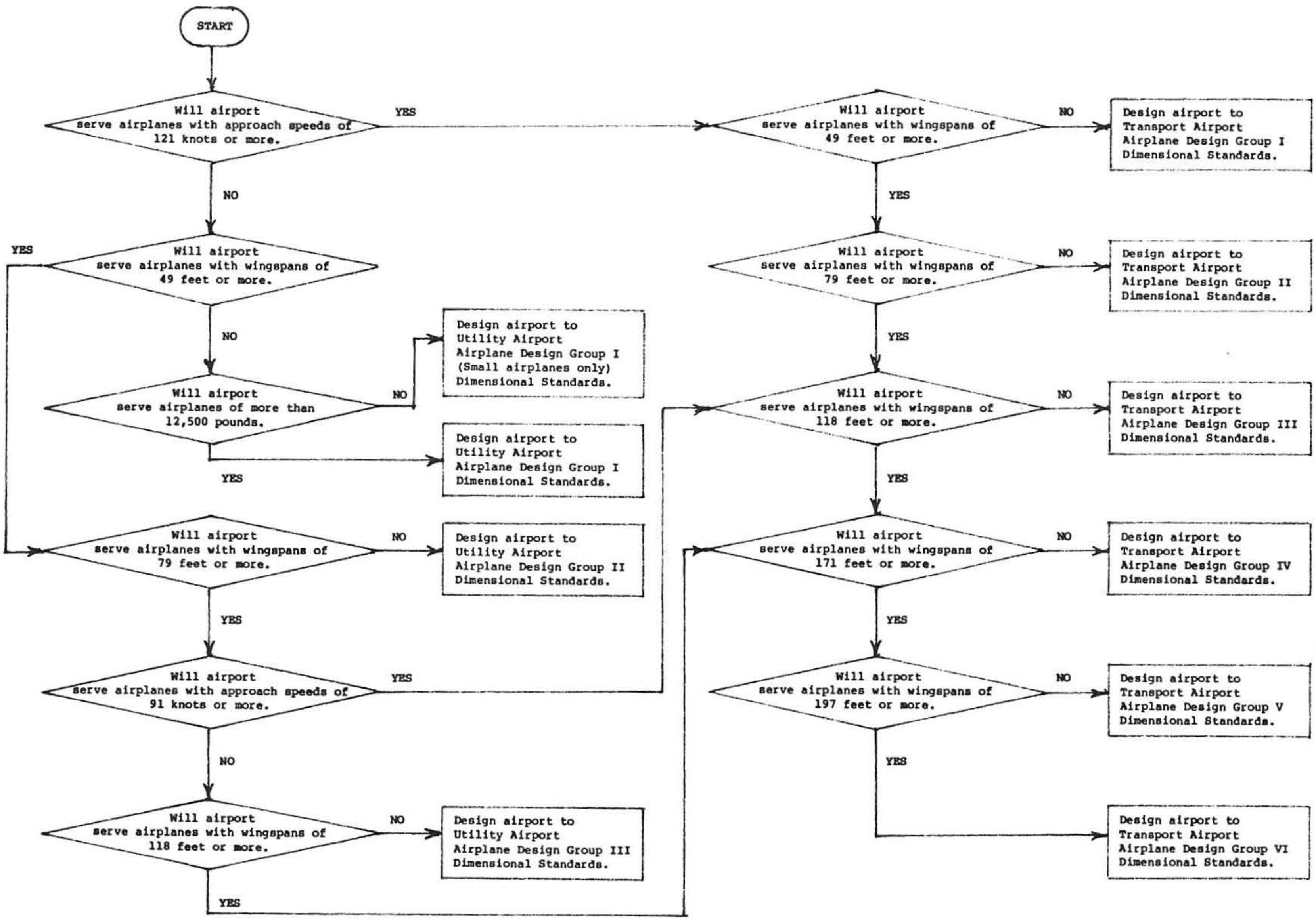
f. Specifications are an essential part of the total data needed for construction. They stipulate information pertaining to the method and manner of performing the work, as well as the quantities and quality of materials to be furnished under the contract. Federally aided projects require use of the specifications given in AC 150/5370-10, Standards for Specifying Construction of Airports, current edition, or use of an acceptable substitute, such as a pertinent specification of the State Highway Department. In any event, local conditions, practices, and needs must be considered in the compilation of the project specifications. As a general guideline, prepare concise and simple specifications. The decision to use local materials should be based on an economical analysis and local experience.

(1) Included in the typical set of plans are references to typical specifications given in AC 150/5370-10. For example, the base course for a flexible pavement is referenced to FAA Specification Number P-208, Aggregate Base Course.

(2) Depending upon local conditions, the engineer may wish to use specification P-208 within the scope of the standard specification by selecting the proper variables such as the aggregate gradation or by modifying it to meet specific local conditions. A comparable state highway specification could be substituted for the P-208 depending on the economics of the individual situation.

87. METRIC APPLICATION. As momentum for the transition to the metric system develops, the probability of metric construction drawings will increase and will eventually become a reality. Therefore, in order to become acquainted with the factors and philosophy involved with producing metric drawings, the reader is directed to the concepts and references developed in chapter 14. *

APPENDIX 1. AIRPLANE DESIGN GROUP CONCEPT



APPENDIX 2. PRELIMINARY ENGINEERING CHECKLIST FOR FIELD INVESTIGATION

City ______________ County ______________ State ______________

1. Local name of site ______________

2. Location:

   (a) Coordinates: Latitude ______________ Longitude ______________

   (b) Elevation ______ feet msl.

   (c) Section, Township, Range ______________

   (d) Relation to nearest communities ______________

   (e) Relation to other airports ______________

   (f) Aeronautical Chart ______________

   (g) U.S.G.S. Quadrangle Sheet ______________

   (h) Department of Agriculture aerial photograph ______________

3. Climatological data:

   (a) Annual rainfall ____ inches Frost penetration ____ inches Snowfall ____ inches

   (b) Prevalence of smoke ________ Fog ________ Flooding ______________

   (c) Prevailing winds: Summer ________ Winter ________

   (d) Normal maximum temperature of hottest month ________°F

   (e) Source of meteorological data ______________

   ____

   (f) Unusual weather conditions ______________

   ____

4. Preliminary design data:

(a) Airport category ____________

(b) Recommended runway length ______ feet

(c) Percent wind coverage ____________

(d) Crosswind runway length ____________

(e) Type & Direction of instrument procedure ____________

5. Site clearing:

(a) On-site acreage ____________

(b) Approach area acreage ____________

(c) Other obstructions ____________ (trees, power lines, roads, etc.)

6. Soils survey:

(a) Number of borings ____________

(b) Estimated depth of water table ____________

(c) Federal Aviation Administration soil classification ____________

(d) Noteworthy features (stony, swampy, type cover, etc.) ____________

____

7. Drainage:

(a) Natural drainage courses ____________

____

(b) Total tributary area acreage ____________

(c) Method of estimating runoff ____________

____

(d) Major drainage structures anticipated ____________

8. Grading:

(a) Unclassified excavation (cut and fill) ______________________ cu. yd.

(b) Borrow material ______________________cu. yd.

9. Preliminary pavement design:

(a) Thickness of compacted subgrade ______________________

(b) Thickness of subbase ______________________

(c) Thickness of base course __________

(d) Thickness of wearing surface ______________________

(e) Distance to base material ______________________

(f) Location of asphaltic concrete plant______________________

(g) Length and width of access road ______________________

10. Turfing:

(a) Specie chosen ______________________

(b) Total area to be turfed ______________________ acres

11. Airfield lighting:

(a) Type of lighting ______________________

____

(b) Other visual aids (such as AVASI, REILS, etc.) ______________________

(c) Obstruction lighting ______________________

12. Utilities:

(a) Water supply source ______________________

(b) Sewerage—disposal system ______________________

(c) Telephone source ______________________

(d) Power—KVA available ______________________

(e) Gas—supply source ______________________

13. Estimated cost for airport construction:

Item	*Unit*	*Unit Cost*	*Quantity*	*Amount*
a. Clearing, on-site	Acre	________	________	________
b. Clearing, off-site	Acre	________	________	________
c. Obstruction removal	L.S.1/	________	________	________
d. Unclassified excavation	Cu. Yd.	________	________	________
e. Borrow	Cu. Yd.	________	________	________
f. Drainage				
(a) Pipe	L. Ft.	________	________	________
(b) Structure	L.S.	________	________	________
(c) Other		________	________	________
g. Pavement				
(a) Airport	Sq. Yd.	________	________	________
(b) Road	Sq. Yd.	________	________	________
h. Turfing	Acre	________	________	________
i. Lighting	L.S.	________	________	________
(a) Runway, Taxiway, Apron, and Beacon		________	________	________
(b) Visual Aids		________	________	________
(c) Obstruction		________	________	________
j. Utilities				
(a) Water	L.S.	________	________	________
(b) Sewage	L.S.	________	________	________
(c) Other		________	________	________
k. Miscellaneous				
(a) Fencing	L. Ft.	________	________	________
(b) Runway marking	L.S.	________	________	________
(c) Segmented Circle and Wind Cone (lighted or unlighted)	L.S.	________	________	________
			TOTAL:	________

1/Lump Sum

14. Total estimated cost for:
Engineering, Supervision, Inspection and Administration, and Construction Contingencies TOTAL ________

15. Total Estimated Cost for Airport Project (excluding land acquisition) TOTAL ________

COMMENTS: ____________________________________

____

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Date of
Investigation: ________________ Engineer: ________________________

* APPENDIX 3. ANALYZING WIND DATA

1. OBJECTIVE. Airport runways should be oriented so that pilots are not compelled to cope with excessive crosswinds. This appendix provides guidance on the assembly and analysis of wind data to determine the runway orientation which minimizes the probability of operating with excessive crosswinds. It may also be used to analyze the operational impact of winds on existing runways.

2. ASSEMBLING WIND DATA. The latest and best wind information, i.e., 36 directions and standard speed groupings, should always be used to carry out a wind analysis. A record which covers the last ten consecutive years of wind observations is preferred. Records of lesser duration may be acceptable on a case-by-case basis. In some instances, it may be highly desirable to obtain and analyze wind information for periods of particular significance; i.e., seasonal variations, instrument weather conditions, daytime versus nighttime, etc.

   a. Data Source. The best sources of wind information is the National Oceanic and Atmospheric Administration, Environmental Data Service (EDS). The EDS's National Climatic Center, located in the Federal Building, Asheville, North Carolina 28801, is the repository of wind information from recording stations throughout the Nation. The Center should be contacted directly to determine the availability of data for a particular site.

   b. Data Costs. The EDS provides wind information at cost. The cost will vary, depending upon the complexity of the information desired, how the data are being stored, and whether the data have been assembled (summarized) previously. When the wind summary must be assembled for the airport site, the data should be formatted with the standard 36 wind directions and usual speed groupings. (See figure 2.) An existing wind summary of recent vintage is acceptable for analysis purposes if these standard wind direction and speed groupings are used. Figure 1 is included as an example of a typical EDS wind summary using standard wind directions and wind speed groupings, e.g., 0-3 kts, 4-6 kts, 7-10 kts, 11-16 kts, 17-21 kts, 22-27 kts, 28-33 kts, 34-40 kts, etc.

   c. Data Not Available. In those instances when EDS data are not available for the site, it is permissible to develop composite wind data using wind information obtained from two or more nearby recording stations. These composite data are usually acceptable if the terrain between the stations and the site is level or only slightly rolling. If the terrain is hilly or mountainous, composite data may only have marginal validity. In extreme cases it may become necessary to obtain a minimum of 1 year of on-site wind observations. These meager records should be augmented with personal observations (wind-bent trees, interviews with natives, etc.) to ascertain if a discernible wind pattern can be established. Airport development should not proceed until adequate wind data are acquired.

3. ANALYZING WIND DATA. The wind analysis procedure uses a scaled graphical presentation of wind information known as a windrose.

   a. Drawing the Windrose. The standard windrose (figure 2) is a series of concentric circles cut by radial lines. The perimeter of each concentric circle represents the division between successive wind speed groupings. *

* Radial lines are drawn so that the area between each successive pair is centered on the direction of the reported wind. The example windrose shows 36 wind directions, the EDS standard for noting wind directions since January 1, 1964.

b. Plotting Wind Data. Each segment of the windrose represents a wind direction and speed grouping corresponding to the wind direction and speed grouping on the EDS summary. The recorded directions and speeds of the wind summary are converted to a percentage of the total recorded observations. This percentage value is entered in the appropriate segment of the windrose. Entries may be rounded to the nearest one-tenth of one percent. Figure 3 illustrates a completed windrose based on data from figure 1. Plus (+) symbols are used to indicate direction and speed combinations which occur less than one-tenth of one percent of the time.

c. Crosswind Template. A transparent crosswind template can be a useful aid in carrying out the windrose analysis. The template is essentially a series of three parallel lines drawn to the same scale as the windrose circles. The allowable crosswind for the airplane grouping expected to be served by the runway establishes the physical distance between the outer parallel lines and the centerline. The standard distance is 10.5 knots for runways under 100 feet (30 m) in width and 13 knots for all other runways. When analyzing the wind coverage for an existing runway orientation, the design crosswind limit lines can be drawn directly on the windrose. NOTE: EDS wind directions are recorded on the basis of true north.

d. Analysis Procedure. The purpose of the analysis is to determine the runway orientation which provides the greatest wind coverage within the allowable crosswind limits. This can be readily estimated by rotating the crosswind template about the windrose center point until the sum of the individual segment percentages appearing between the outer "crosswind limit" lines is maximized. It is accepted practice to total the percentages of the segments appearing outside the limit lines and to subtract this number from 100. For analyses purposes, winds are assumed to be uniformly distributed throughout each of the individual segments. Figures 4 and 5 illustrate the analysis procedure as it would be used in determining the wind coverage for a runway, oriented 105°-285°, intended to serve all types of airplanes. The wind information is from figure 1. Several trial orientations may be needed before the orientation which maximizes wind coverage is found.

4. CONCLUSIONS. The example wind analysis shows that the optimum wind coverage possible with a single runway and a 13-knot crosswind is 97.28 percent. If the analysis had shown that it was not possible to obtain at least 95 percent wind coverage with a single runway, then consideration should be given for providing an additional (crosswind) runway oriented to bring the combined wind coverage of the two runways to at least 95 percent.

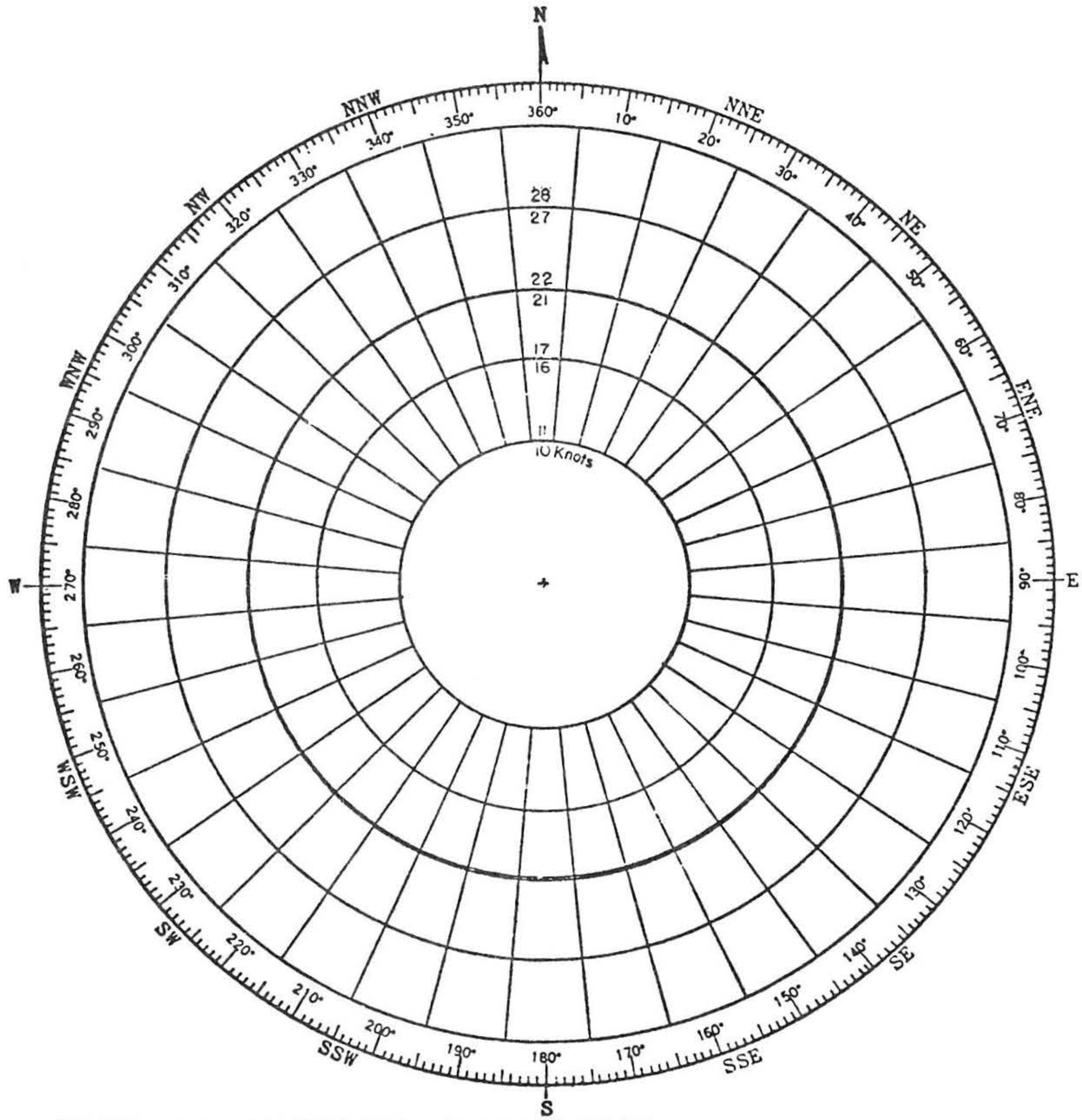
5. PRESUMPTIONS. The analysis procedures presume that winds are uniformly distributed over the area represented by each segment of the windrose. The larger the area, the less accurate is this presumption. Therefore, calculations made using nonstandard windrose directions or speeds result in a derivation of wind coverage (and its associated justification for a crosswind runway) which is questionable. The analysis of a standard windrose, based on seasonal weather and day-night variations, etc., should be undertaken whenever possible. *

WIND DIRECTION VERSUS WIND SPEED

STATION: Anywhere, USA HOURS: 24 Observations/Day PERIOD OF RECORD: 1964-1973

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED										AVERAGE SPEED	
	KNOTS 0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41 OVER	TOTAL	KNOTS	MPH
	MPH 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47 OVER			
01	469	842	568	212						2091	6.2	7.1
02	568	1263	820	169						2820	6.0	6.9
03	294	775	519	73	9					1670	5.7	6.6
04	317	872	509	62	11					1771	5.7	6.6
05	268	861	437	106						1672	5.6	6.4
06	357	534	151	42	8					1092	4.9	5.6
07	369	403	273	84	36	10				1175	6.6	7.6
08	158	261	138	69	73	52	41	22		814	7.6	8.8
09	167	352	176	128	68	59	21			971	7.5	8.6
10	119	303	127	180	98	41	9			877	9.3	10.7
11	323	586	268	312	111	23	28			1651	7.9	9.1
12	618	1397	624	779	271	69	21			3779	8.3	9.6
13	472	1375	674	531	452	67				3571	8.4	9.7
14	647	1377	574	281	129					3008	6.2	7.1
15	338	1093	348	135	27					1941	5.6	6.4
16	560	1399	523	121	19					2622	5.5	6.3
17	587	883	469	128	12					2079	5.4	6.2
18	1046	1984	1068	297	83	18				4496	5.8	6.7
19	499	793	586	241	92					2211	6.2	7.1
20	371	946	615	243	64					2239	6.6	7.6
21	340	732	528	323	147	8				2078	7.6	8.8
22	479	768	603	231	115	38	19			2253	7.7	8.9
23	187	1008	915	413	192					2715	7.9	9.1
24	458	943	800	453	96	11	18			2779	7.2	8.2
25	351	899	752	297	102	21	9			2431	7.2	8.2
26	368	731	379	208	53					1739	6.3	7.2
27	411	748	469	232	118	19				1997	6.7	7.7
28	191	554	276	287	118					1426	7.3	8.4
29	271	642	548	479	143	17				2100	8.0	9.3
30	379	873	526	543	208	34				2563	8.0	9.3
31	299	643	597	618	222	19				2398	8.5	9.8
32	397	852	521	559	158	23				2510	7.9	9.1
33	236	721	324	238	48					1567	6.7	7.7
34	280	916	845	307	24					2372	6.9	7.9
35	252	931	918	487	23					2611	6.9	7.9
36	501	1568	1381	569	27					4046	7.0	8.0
00	7729									7729	0.0	0.0
TOTAL	21676	31828	19849	10437	3357	529	166	22		87864	6.9	7.9

FIGURE 1. TYPICAL ENVIRONMENTAL DATA SERVICE WIND SUMMARY



WIND SPEED DIVISIONS		RADIUS OF CIRCLE (KNOTS)
KNOTS	M.P.H.	
0 - 3.5	0 - 3.5	* 3.5 Units
3.5 - 6.5	3.5 - 7.5	* 6.5 "
6.5 - 10.5	7.5 - 12.5	10.5 - "
10.5 - 16.5	12.5 - 18.5	16.5 - "
16.5 - 21.5	18.5 - 24.5	21.5 - "
21.5 - 27.5	24.5 - 31.5	27.5 - "
27.5 - 33.5	31.5 - 38.5	*33.5 - "
33.5 - 40.5	38.5 - 46.5	*40.5 - "
40.5 - over	46.5 - over	

*May not be needed for most windrose analyses.

FIGURE 2. WINDROSE BLANK SHOWING DIRECTION AND DIVISIONS

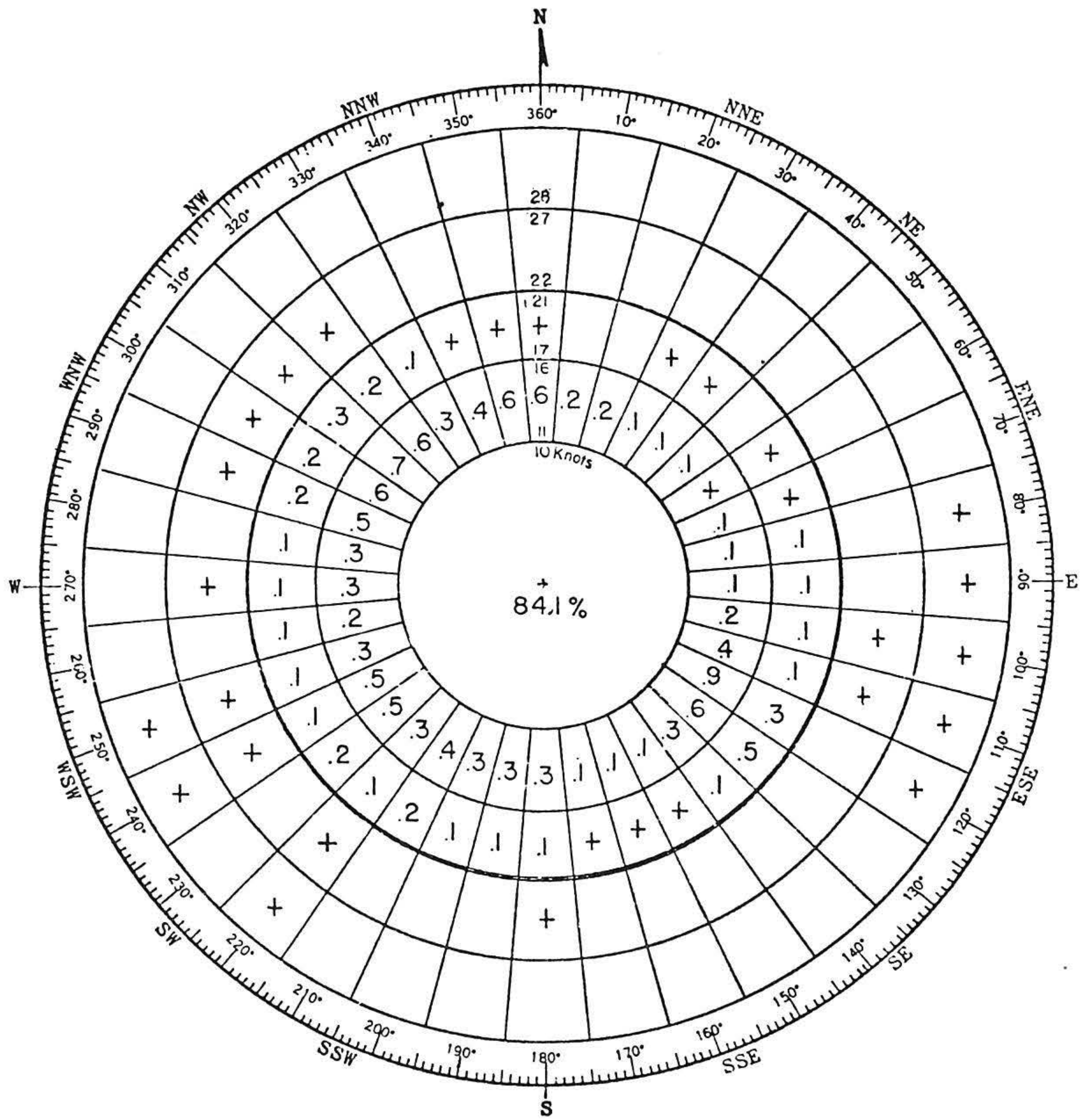
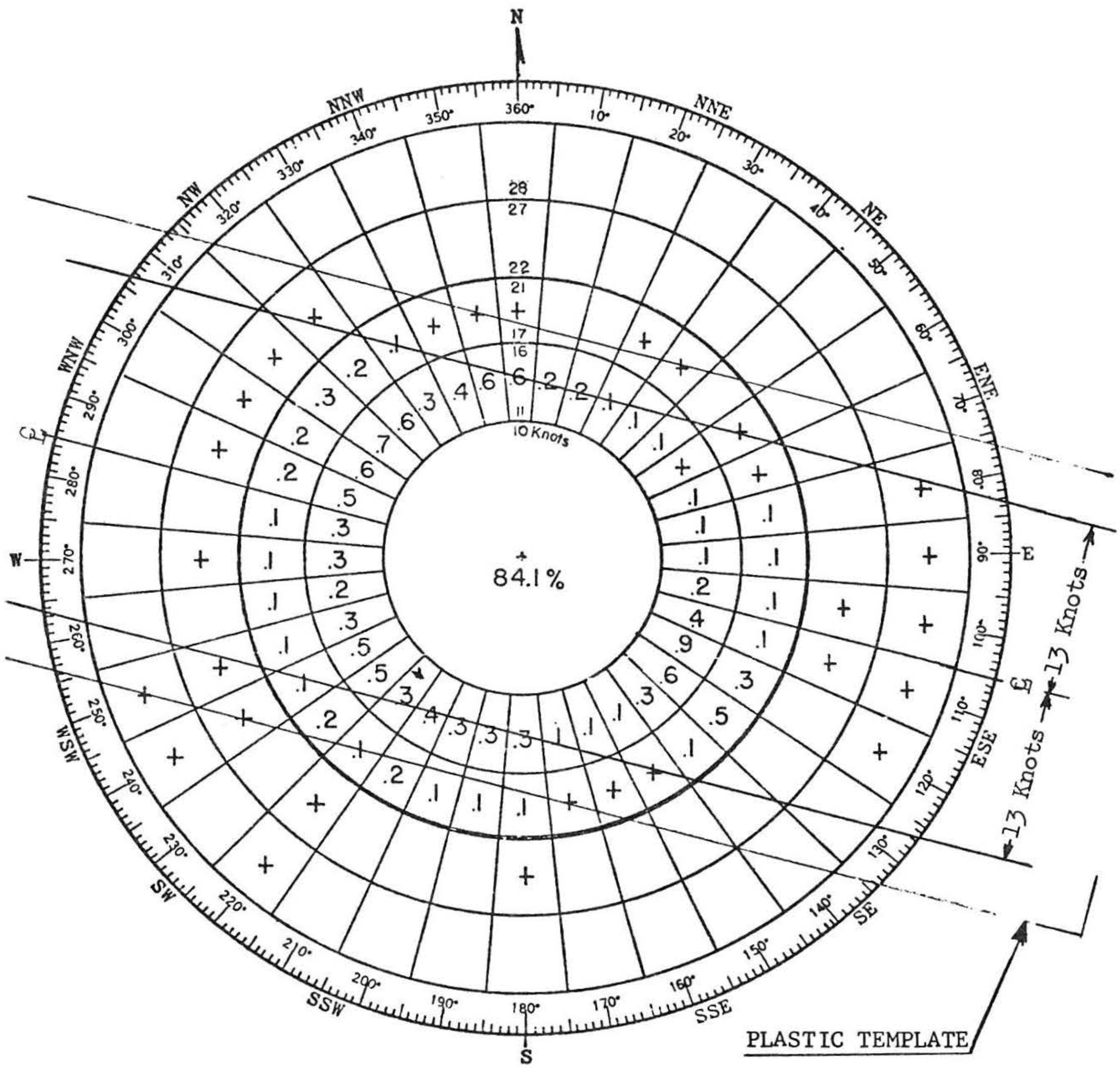


FIGURE 3. COMPLETED WINDROSE USING FIGURE 1 DATA



A runway oriented 105°-285° (true) would have 2.72% of the winds exceeding the design crosswind/crosswind component of 13 knots. (See Figure 5.)

FIGURE 4. WINDROSE ANALYSIS

DIRECTION	ESTIMATED AREA NOT INCLUDED			
	11-16	17-21	22-27	28+
10	.12			
20	.12			
30	.05	+		
40	.04	+		
50	.01			
60		+		
70				
80			.01	+
90				
100				
110				
120				
130			.01	
140		.01		
150		+		
160	.01	+		
170	.04	+		
180	.14	.10	+	
190	.16	.10		
200	.16	.10		
210	.20	.20	+	
220	.11	.10	+	+
230	.03	.19		
240		.05	+	+
250		.01	+	+
260				
270				
280				
290				
300				
310				
320		.01	+	
330		.05		
340	.04	+		
350	.25	+		
360	.30	+		
SUM	1.78	.92	.02	+

1.78
.92
.02
2.72

100.00
2.72
97.28

100.00 - SUM = Coverage

100.00 - 2.72 =97.28% Coverage

FIGURE 5. WINDROSE ANALYSIS--ESTIMATING AREA NOT INCLUDED

APPENDIX 4. TYPICAL SET OF PLANS

1. INTRODUCTION TO USE. This set of plans is intended to be used for guidance and as graphic aid in obtaining up-to-date plans for airport construction. These plans are for a typical but hypothetical airport. Neither the layout nor the construction details shown will necessarily be suitable for an actual location. Therefore, they should not be utilized as "standards" from which details can be copied. Only qualified engineers should prepare the construction plans for any airport development.

2. SPECIFICATIONS. The set of plans must be supplemented by appropriate specifications to provide all data required for material and construction. Discussion of the background and other information is contained
* in Chapter 15, Construction Plans.

3. SIZE OF PLANS. The original drawings were on sheets 24 by 36 inches (including margins). This is the size for plans to be submitted to the FAA for approval. *