AN ELEMENTARY SCHOOL
FOR
ROANOKE, VIRGINIA

by
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for the Degree of
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in
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Approved:

Head of Department

Dean of Engineering

Chairman, Graduate Committee

Virginia Polytechnic Institute
1949
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The author wishes to acknowledge the help received from Professor H. H. Waechter, Design Critic; Professor J. F. Poulton, Structural Design Critic; Mr. D. E. McMillan, Superintendent of Schools for Roanoke, and his Secretary; and Mr. B. N. Subank, Roanoke architect. Deep appreciation is given to Professor C. H. Cowgill, Head of the Department of Architecture, for guidance received in the preparation of this thesis.
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I

INTRODUCTION
INTRODUCTION

The primary purpose of this thesis is to investigate and analyze the present conditions and trends of elementary school education in the United States and in Roanoke, Virginia, and to make recommendations for the planning and design of future schools. The secondary purpose of this thesis is the design of an elementary school for a specific site in Roanoke, utilizing the information obtained from the research.

The author feels that a new and entirely different approach should be taken in the design of schools, as to functions and cost, than has been previously followed in Virginia. The author recognizes the value and need of higher quality instruction in Virginia schools, but he also feels that, in order to obtain this type of instruction, more and better housed facilities are needed as well as qualified teachers.
II

EDUCATION IN GENERAL
EDUCATION IN GENERAL

This is a brief analysis of the educational, psychological, sociological, and economic conditions and requirements which have to be considered in designing a school.

A child's development depends mainly on two things: heredity and environment. The effects of heredity cannot be changed to a great extent, but environment is a variable which can be changed to give the greatest benefit. Environment is of the greatest importance for the development of the child and should be as ideal as possible. One of the primary components of proper environment is education. Because of economic or social reasons and the general lack of training and qualification of the parents, proper education is often considered lacking in the home and is, therefore, provided in the public schools. The elementary school should be considered a supplement for, not a substitute for, the home. (1)

1. THE UNITED STATE:

Public education in the United States has been recognized more and more since the beginning of the nineteenth century and is now mandatory in most states for all children under sixteen.

(1) "Proposals for Public Education in Postwar America" National Education Association of the United States Washington, D. C. 1944 Page 9
years of age (2). If this country has not been the world's center of education, it should be now since World War II. In this country the physical facilities devoted to education have remained intact, the program of scientific and educational advances has not been impaired, and the vision of future possibilities and responsibilities has been clearly seen by some of our leaders. The expansion of educational facilities and opportunities in this country is inevitable; the demand is imperative. The understanding of international problems, as well as national problems, depends largely on the education of our people.

The facilities for such broadening of educational programs must be found in the community schools, as well as in other community facilities devoted to the intellectual, social, and vocational improvement of our people. Nearly two decades have passed during which few school buildings have been constructed either as additions to existing school facilities or as replacements (see Figure I, Page 4). According to Mr. McLeary, in "The School Building Crisis," this lack of school construction has been caused by economic factors and, since World War II, by continued shortages, public inertia, and price levels which have frightened the tax payers. Twenty years without replacements, without renovation, and generally

2. Ibid Page 5
**FIGURE I**

PERCENT OF SCHOOL BUILDINGS ERECTED AT DIFFERENT INTERVALS

AND THE PERCENT OF PUPILS ENROLLED IN THEM (3)

<table>
<thead>
<tr>
<th></th>
<th>Before 1870</th>
<th>1870-1899</th>
<th>1900-1929</th>
<th>1930-1939</th>
<th>Since 1940</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings erected during each period</td>
<td>2</td>
<td>20</td>
<td>57</td>
<td>16</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>15</th>
<th>60</th>
<th>19</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils enrolled in buildings of various ages</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Percent | 0 | 25 | 50 | 75 | 100 |

without satisfactory maintenance, have made the American schoolhouse in general obsolete, inadequate, unhealthful, uncomfortable, and, in many cases, unsafe. Added to this is the transformation in the objectives and in the procedures of the schools. The educational program today, particularly in the elementary schools, is markedly different from what it was in 1930 (4).

"The elementary school child is at a stage of transition. His surroundings should be healthful and unoppressive, his education stimulated by short creative tasks, gentle doses of the three R's, and communal activities in not too large groups" (5).

Besides the overcrowded conditions (see Figure II, page 6) due to lack of construction, to the use of unsafe, temporary, or rented space, and to the change in educational trends, there is still another factor which must be taken into consideration. This is the increased birth rate during and since World War II which will increase the present enrollment of schools to almost half again as much by 1958 (see Graph I, Page 7).

There are a number of ways by which the cost of construction of these necessary new facilities may be met (6): (A) Sinking fund bonds, (B) Long term serial-bonds, (C) Pay-as-you-go, (D) State assistance, (E) Federal assistance. The first three

   School Management, Volume 18, Number 5, November 1948 Page 3
5. Design of Nursery and Elementary Schools, by H. M. wright and R. G. Herwin
6. "Planning the School Plant Program"
   Ray L. Hamon, United States Office of Education
   The American School and University --- Eighteenth Annual Edition
FIGURE II
EXCESS OF ACTUAL ENROLLMENT OVER RATED CAPACITY FOR THE
OVERCROWDED SCHOOL BUILDINGS REPORTED
BY 1597 CITY SYSTEMS (7)

<table>
<thead>
<tr>
<th>TYPE OF SCHOOL</th>
<th>(Rated capacity - 100%)</th>
<th>(Overload)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary</td>
<td></td>
<td>(31)</td>
</tr>
<tr>
<td>Junior High</td>
<td></td>
<td>(26)</td>
</tr>
<tr>
<td>Senior High</td>
<td></td>
<td>(29)</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>(38)</td>
</tr>
<tr>
<td>All Types</td>
<td></td>
<td>(31)</td>
</tr>
</tbody>
</table>

7. Supra (5) Page 150
GRAPH I
ESTIMATED ENROLLMENT IN ELEMENTARY AND HIGH SCHOOLS (8)

Millions

1947 '48 '49 '50 '51 '52 '53 '54 '55 '56 '57 '58 '59 '60

3. "War Babies Will Increasingly Swamp the Schools" George J. Hecht, Publisher of School Management School Management, Volume 18, Number 2, September 1948
methods of financing schools are handled either by the state or by the local community. The adequacy of the school facilities provided depends entirely on the financial conditions of the state or local community. State assistance as now proposed would give more uniform results throughout the state; Federal assistance, however, if provided through the state educational system, according to needs and effort, would give a more uniform national result.

Under the Constitution of the United States, educational powers have been vested in the states. The states, in general, have delegated most of the educational authority to the local communities or districts.

"The strongest and most effective state departments work on a service basis rather than on the basis of control over the local school districts, and such departments operate with the full support of the local school authorities and the people." (9)

The present federal agency, the United States Office of Education, is prepared to give special service to the states and local communities as advisors and coordinators (10), but it has a comparatively small place in the federal budget, (see Figure III, Page 9). The appropriation for education is approximately 3/100 of one percent of the present appropriation for national

9. "Educational Relationships, Federal, State, and Local" Edgar Fuller, Executive Secretary, National Council of Chief School Officers; School Management, Volume 18, Number 5, December 1948

10. "Educational Planning; The United States Office of Education The School Executive, Volume 66, Number 10, June 1947
### Figure III

**Comparison of Expenditures for Education with Other Federal Programs for 1939 (II)**

<table>
<thead>
<tr>
<th>Annual Cost</th>
<th>Ratio</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$18,000,000</td>
<td>1</td>
<td>Housing</td>
</tr>
<tr>
<td>47,000,000</td>
<td>2.4</td>
<td>Education</td>
</tr>
<tr>
<td>257,000,000</td>
<td>14.2</td>
<td>Public Highways</td>
</tr>
<tr>
<td>290,000,000</td>
<td>15.7</td>
<td>Civilian Conservation Corps</td>
</tr>
<tr>
<td>345,000,000</td>
<td>18.6</td>
<td>Social Service and R.R. Retirement</td>
</tr>
<tr>
<td>582,000,000</td>
<td>30.8</td>
<td>Veterans' Pensions and Benefits</td>
</tr>
<tr>
<td>787,000,000</td>
<td>42.6</td>
<td>Agricultural Adjustment Program</td>
</tr>
</tbody>
</table>
defense. Several bills have been introduced in Congress favoring national coordination and equalization of education. The present legislation before the Eighty-first Congress provides that the federal government assist each state in providing a minimum of $55 a year for each pupil. The money would be paid out of the United States Treasury into the treasuries of the respective states. There the money would be spent for operating the schools by the same authorities who expend the state funds for education. The bill implies that control of education shall remain in the hands of the states and communities (12).

2. ROANOKE

In Roanoke the present conditions of existing school buildings, as well as the need for additional educational facilities, are typical of the nation as a whole. According to the Superintendent of Schools of the city of Roanoke, only one school building has been constructed since 1928, and that is the new Monroe Junior High School. Many of the existing school buildings should be replaced or repaired, and there is a general tendency toward overcrowding. Besides repair of many existing facilities and replacement of others, the increased birth rate (see Graph II, page 11) of the city makes more schools necessary (see Graph III, Page 12). The peak enrollment

12. "Bill to Grant $300,000,000 for Schools
Associated Press, Richmond Times-Dispatch, March 18, 1949
13. "Why Roanoke Needs a School Building Program"
Art Printing Company, Roanoke, Virginia, 1949 Page 2
Graph III

Estimated Enrollment (14)

1949 1954 1959 1964

is expected in the elementary schools by 1954 and in the high schools in 1960. This makes it imperative that elementary schools have priority in the proposed school building program.

The school building program will be financed by a bond issue which was voted on and accepted by the freeholders of Roanoke, March 1, 1949. This bond issue consists of term bonds which will be recalled by 1961 and refinanced with serial bonds at a lower rate of interest. These serial bonds will come due over a period of thirty years and will be financed by an increase in real estate taxes, personal property taxes, and utility taxes, if Roanoke can sell the bonds at two and one half percent (15).

According to the Superintendent of Schools of Roanoke, the only authority the Virginia Department of Education has is to examine and pass on the plans and specifications of each school building.

3. GENERAL TRENDS IN EDUCATION (16)

A. School mental health program:

(1) Counseling for all who desire help; parents and teachers as well as children.

(2) Vocational guidance.

(3) Tests of academic achievements and intelligence.

(4) Group therapy.


III

ANALYSIS OF SCHOOL PLANNING
B. Aid to physically handicapped.
C. Teachers for home-bound children.
D. Services for exceptionally intelligent children.
E. Development of 12-month school program.
F. Planned health and physical education program.
G. Development of the hands, social ability, as well as the mind.
H. Communal activities such as music and exercises, singing, dancing, small dramatic shows, and exhibitions of slides or short films.
I. Pre-schools for three to seven year olds.
J. The school as a community center:
   (1) Service to community organisations.
   (2) Health services.
   (3) Adult education.
   (4) Cultural, social, recreational, and other community services.
K. Greater use of audio-visual aids.
L. Designers seek expansibility and flexibility.
M. More emphasis on landscaping of grounds.
N. Higher standards in matters of accessibility in buildings, rooms, equipment, and playgrounds.
O. Rooms planned for multiple uses.
ANALYSIS OF SCHOOL PLANNING

1. THE SITE:

Coordination of city planning and school planning is necessary in order to have the proper zoning for school surroundings. An industrial area would not be the proper location for a school because the smoke and dust would form menaces to the health of the children, and the noise would be a distracting influence. The latter reason also applies to areas of heavy traffic. The elementary school should be located in the center of the area that is to be served, and the radius of this area should be no more than three-quarters of a mile (17). The school property must be dry, high ground for the best health conditions and sufficiently pitched to shed surface water quickly. The soil should be porous enough to permit rapid seepage, but with enough body to minimize dust and nourish grass and shrubbery.

Five acres is considered the minimum size of the elementary school site with an additional acre provided for each one hundred pupils of the expected enrollment (18). This area should allow for adequate play area; 272 square feet per pupil (19); and for

17. American School Buildings -- Twenty-seventh Yearbook
   National Education Association of School Administrators
   Washington, D.C. 1949 Page 73
18. Ibid Page 75
   Reprint from Virginia School Laws, Part VII
   Regulations of the State Board of Education
   The Michie Company, Printers, 1944  Page 4
setting the building back from the street for proper landscaping and noise insulation. The site should be well proportioned to allow for ease of development and expected future expansion. It is reasonable to expect that the value of the adjacent land will increase after the school has been built. In the meantime the land that has been purchased for the expansion will serve well as an addition to the play area of the school. Orientation of the building is important, if expansion is expected, so that necessary wings may be added in the future without bringing them too close to the property line.

Landscaping sets the building off to an advantage and adds cheerfulness and beauty to the school site. This cheerfulness will pervade the entire school and will be reflected in countless ways in the work of the student. Shade trees must be kept away from the windows so they will not darken the rooms. Elevated sites on the tops of ridges and knolls offer innumerable possibilities for attractive landscaping as well as drainage.

"Landscaping plans shall provide for a complete landscaping program, including grading, terracing, and planting, and shall include proper arrangement for play areas, parking areas, etc." (20).

In order to obtain the best results, a landscape architect should be consulted when the site is being planned, and a comprehensive planting scheme worked out.
It is considered necessary, for the safety of the children, to plan circulation so that pedestrian traffic does not cross vehicular traffic lanes and parking areas (21). Playgrounds should be away from the main roads, and bicycle racks placed in such a position as to avoid cross circulation with vehicular traffic.

"Driveways and walks must be so planned and specified that children may enter and leave the building without walking in mud, must provide for loading and unloading pupils on hard surfaced areas, must make satisfactory provisions for the delivery of fuel and supplies to the building, and must provide adequate parking for automobiles" (22).

The playgrounds should be easily accessible to the class rooms and to the assembly room.

Recreational areas provide facilities for a variety of outdoor activities for pupils of all ages and for adults, if the school is to have community uses. Such facilities as jungle gyms, slides, sand boxes and space for informal games are provided for small children. The areas for older elementary school pupils provide space for such informal games as hopscotch and shuffle-board and for such organized games as softball and track. A small play house and other pieces of playing apparatus should also be provided.

21. Supra (17) Page 77
22. Supra (19) Page 4
2. THE BUILDING

Circulation throughout the building must provide for a minimum of cross-circulation. The entrance and lobby are immediately accessible to the pupils and the public, and the lobby should be large enough to hold all the pupils before morning physical inspection. Staff entrances as well as service entrances are preferably independent of student entrances. Corridors must be free of any projections, and in places of heavier circulation corridors must be widened to take care of the increase, but sudden reductions in width should be avoided. The Virginia School Building Code gives special requirements for entrances, exits, stairs, and corridors. (23).

Offices of the administration should be planned so that they are easily accessible from the main center of activity within the building and also accessible to the public. The office of the principal is planned so that it connects with the general offices and also with the lobby or corridor, and it should be furnished with a fire vault or a large built-in safe for the storage of records and valuable papers. A general office is usually provided for the clerks and an area may be provided at one end for the public waiting room separated from the general office by a counter. A small council room, approxi-

23. Supra (19) Pages 5-6
mately half the size of a classroom, used for teachers’ meetings and parent-teacher conferences may be adjacent to these offices. A small storage room for supplies should be convenient to the general offices. If school books are furnished by the school board, adequate storage space and a distribution point must be convenient to the general offices. Two types of areas, a rest room and a work room, are usually provided for the teachers. The rest room is furnished with easy chairs, couches, bookshelves and magazine racks, and tables for quiet study. In a small elementary school the work room may be combined with the library. It must have a work counter and sink, chairs, tables, bookshelves, supply cabinets, a typewriter and duplicating machine. One or more janitor’s closets equipped with slope sink and shelves are needed. In a small elementary school, the janitor’s workshop and dressing room may be combined with the heater room.

The elementary school classroom is planned to fit the educational program. It is the opinion of most specialists that a modern elementary school program requires a minimum of thirty square feet of floor area per pupil, exclusive of storage areas. An elementary school classroom includes ample storage cabinets and pupils’ lockers, either built-in or freestanding. These cabinets may serve as temporary or permanent separations between different areas. The temporary set-up is usually preferable,
so that a maximum size area may be possible when desired. Desks must be scaled to the children and may be either the individual type or tables and chairs, depending on the requirements. A sink and work counter are now considered standard equipment in every elementary class room, and for pupils of from five to seven years of age, one water closet and one lavatory should be provided in connection with every class room. Tack board and chalk board are provided at eye level of the pupils who use the room. A separate resting area is desirable but not necessary for the primary classes, but space should be provided for the storage of cots or pallets when they are not in use. The storage closet for the teacher is separate from the pupils' locker area. Outdoor class areas connected directly with the inner class rooms have been used successfully, especially in warm climates. This area is semi-private and at least as large as the inner class room. Part of the outdoor area should be paved for work tables and sink and part turfed or left free for gardening.

The clinic is usually near the general offices, if it is not connected with the physical education facilities. If general health inspections are necessary every morning, the clinic must be near the lobby so that inspection lines may be set up at the rear of the lobby. The clinic area includes a toilet with one water closet and one lavatory, a small labora-
tory, a space for a desk and files for the nurse, storage space for medicine and equipment and an isolation area. The isolation space may be either a curtained-off area or a small room for the temporary use of sick children. Other features may be added if the size of the school warrants.

The elementary school library must provide materials and services for the pupils, and it provides teachers with materials for the educational activities in which their pupils are engaged. The school library may also serve the community after school hours and during the summer. The library must provide areas for reading and circulation, a workroom, storage for books and materials, conference rooms, and possibly audio-visual equipment and supplies. The office of the librarian may be combined either with the circulation desk or the storage room in a small school. The reading room should seat at least twenty more pupils than there are in the largest class. The tables and chairs must be of various sizes to accommodate children of different age groups and individual seats should be furnished for informal reading. Besides tables and chairs, the library includes a circulation desk, card catalogs, files, bulletin boards, magazine and newspaper racks, stools and bookshelves. There must be adequate shelving for books and publications required in the school program; one linear foot of bookshelving for each pupil is considered a minimum (24). In elementary
schools, the bookshelves must not exceed five feet six inches in height and the bottom shelves should be between four and eight inches from the floor; they may be built-in or formed into alcoves. The shelving is usually in sections three feet long, for convenient rearrangement, and eight inches deep with a limited amount ten and twelve inches deep for large books. The work room includes a sink, a closed cabinet for storage, shelving, work tables and chairs and stack space for books and magazines. Space is allotted for the librarian's desk and chair, files, and low shelves for professional books and materials. The conference rooms may be separated from the reading room by clear glass partitions and are equipped with tables, chairs, and shelving. If audio-visual aides are provided, space must be allotted for storage of materials and for seating at least one class (25).

The food service area should be located on the first floor, convenient to a service drive and planned for a minimum of cross traffic. This area provides for the receiving and storage of food, preparation and service of meals, dining, dish-washing, disposal of waste, housekeeping and management. Ten square feet per person is considered adequate in the dining area for the maximum number of pupils to be served at any one time.

22. Supra (17) Pages 111-114
One ten foot serving table or counter will serve about two hundred pupils and, if more are to be served, the counter should be furnished with food warmers. Tables should seat from six to ten pupils to conserve space and chairs are preferable to benches. The dining area should have lighting, both natural and artificial, equivalent to that in the class rooms so it can be used for other purposes before and after meals.

The kitchen area, including dishwashing, requires approximately one and one-half square feet per meal load, with a minimum of 300 square feet. A school lunchroom with a daily meal load of 150-250 will usually require the following basic equipment (26):

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking</td>
<td>Two-section heavy-duty range, with oven</td>
</tr>
<tr>
<td>Sinks</td>
<td>Two-compartment vegetable and pot sink</td>
</tr>
<tr>
<td></td>
<td>Three-compartment dishwashing sink (or</td>
</tr>
<tr>
<td></td>
<td>a single tank dishwashing machine with 20&quot;x30&quot;</td>
</tr>
<tr>
<td></td>
<td>racks)</td>
</tr>
<tr>
<td></td>
<td>Mop sink</td>
</tr>
<tr>
<td></td>
<td>Wash basin</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>60 cubic feet (or 6'x6' walk-in box)</td>
</tr>
<tr>
<td>Tables</td>
<td>Receiving, 24&quot;x 48&quot;</td>
</tr>
<tr>
<td></td>
<td>Cooks' and bakers', 30&quot;x 72&quot;</td>
</tr>
<tr>
<td></td>
<td>Soiled dish, 27&quot;x 72&quot;</td>
</tr>
<tr>
<td></td>
<td>Clean dish, 24&quot;x 48&quot;</td>
</tr>
<tr>
<td>Truck</td>
<td>22&quot;x 10&quot;, 28&quot; high</td>
</tr>
</tbody>
</table>

26. Supra (17); Page 120
Counter

27" to 30" wide x 10' long (exclusive of tray and silver area) with 12" tray rail

Kitchen machine

12-quart mixer on 18" x 24" base.

The amount of storage space required will depend on the availability of supplies, but a minimum of one-half square feet of storage area is usually required per meal served. The storage area must be well ventilated and lighted, vermin-proof, and have shelving and hooks for supplies and cooking utensils. Toilets, washroom, and locker space must be provided near the kitchen for the workers. An office space for the manager is desirable, and it should be provided with a desk, chairs, and files.

In a small elementary school a general purpose room may take the place of the gymnasium and the auditorium. The general purpose room must have a flat floor with a capacity of 200 to 400 seats and a small stage for dramatics and musical programs. This room may be used for movies, and slides, assemblies and other communal activities. The general purpose room may serve also as a recreational area for small children during bad weather and for community uses. There must be storage space for all equipment when not in use. A separate entrance should be provided so that the room may be opened independent of the rest of the building.

Besides the storage areas connected with the class rooms and other special rooms, general storage areas are required for fuel and maintenance supplies and materials. There are
also seasonal equipment and materials which must be stored when not in use and surplus supplies and materials which must be stored until needed. Also there should be space for the storage of trash, hidden from view, until it can be carried away.
IV

MECHANICAL EQUIPMENT
MECHANICAL EQUIPMENT

1. HEATING AND VENTILATING:

Some of the major purposes of heating and ventilation systems are (27): (A) the supply of heat to balance the loss from the human body through radiation, conduction, and evaporation and to balance the losses of heat from the room through exfiltration; (B) the removal of excess heat; (C) the dilution and removal of unpleasant body odors and in some cases direct removal of obnoxious gasses, fumes, and dust; (D) the prevention of rapid temperature fluctuations beyond or even within the total acceptable ranges; and (E) adequate diffusion of heat without excessive stratification or excessive drafts.

Elaborate heating and ventilating plants are not necessary in a small elementary school, but the temperature ranges and air changes desired must be provided and maintained, without overloading, under the most severe weather conditions. The exact amount of fresh air needed for the various activities and rooms is not shown by reliable data, but provisions must be made in all school areas for introducing fresh air into the rooms and exhausting the stale air from them. Minimum air change capacities of 15 cubic feet per person per minute should be provided in all class rooms and libraries (28). Air movement is a vital

27. Supra (17) Page 147
28. Supra (17) Page 148
factor in the comfort of the occupants of a room, and humidification may be provided if desired by introducing moisture into the air. Air cleaning may be necessary in areas where the air may be laden with dust, smoke, or fumes. Controlled heating will mean fuel control, and the smooth operation of the heating plant. Separate controls for different sections of the building should be installed so that only the areas needed are heated.

There are many types of heating and ventilation systems, but the choice of the system to be installed may depend on cost, maintenance and operating services available, size and location of the building, fuel available, and local standards of building and student comfort desired. In a small school air flow can be provided by suitable windows or other local air intakes and by the use of roof ventilators.

The elementary school proposed in this thesis is small, therefore it is considered advisable to make use of projected windows for ventilation rather than installing an elaborate ventilating plant. The classrooms and administration unit have cross ventilation furnished by clerestory windows over the corridors on the exposed side and low strip windows on the south side. The general purpose room is ventilated by means of high windows on the west side and low strip windows on the east side. The cafeteria has low strip windows on the south side and high windows on the north side.
Radiant heating coils in the floor are supplemented by baseboard convectors under the low south windows, thus providing a warm floor surface for the children during rest periods and heating the incoming air before it reaches the occupants of the rooms. This type of heating system is designed to produce a feeling of comfort by surrounding the room occupants with surfaces heated to a temperature that will permit a normal but prevent an excessive heat loss from the body.

2. ELECTRICAL EQUIPMENT:

Besides being used for lighting, electricity may serve many other purposes in a school building. It may be used to operate inexpensive call systems and the fire-alarm system. Radiosound systems are coming more and more into use in connection with the administration, teaching, and extracurricular activities. Even television facilities may be provided if there is any anticipation of a television station being built in the neighborhood in the near future. Conduits should be laid in the floor of any room which is expected to be used for sound-moving pictures.

3. PLUMBING AND SANITARY FACILITIES;

For economic reasons plumbing fixtures may be grouped together, but this should not be carried to the point where educational utility is seriously impaired. Separate toilet rooms
must be provided for each sex, and, where the size of the school warrants, special toilet facilities should be provided for administrators, teachers, and other school employees; toilets should also be provided for the public. For pupils five to seven years of age, the tendency today is to provide toilet facilities in connection with each class room.

"For pupils' toilet rooms, the following ratio of water-closet fixtures to pupils should be considered minimum (at least two water-closets should be installed in each toilet room):

<table>
<thead>
<tr>
<th>Girls</th>
<th>one fixture to 30 pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>one fixture to 60 pupils</td>
</tr>
</tbody>
</table>

"Individual urinals of the floor type should be provided in the ratio of one to each thirty boys using the boys' toilet rooms........ Lavatories or wash basins should be provided in each toilet room in the ratio of one fixture to fifty pupils...

..There should be a minimum of one drinking fountain on each floor and one for each seventy-five pupils....(29).

It is desirable to locate toilet facilities, drinking fountains, and hose outlets at advantageous points on the recreation area. All plumbing facilities must be scaled to the size of the pupils who will use them.

29. Supra (17) Pages 161-166
V

L I G H T I N G
LIGHTING

One of the most important problems to be solved in good school planning and design is that of lighting, both natural and artificial. (Two of the most important objectives to be met in lighting to give good seeing conditions are quality and quantity.) Most school administrators and specialists put good lighting high on their check list of requirements for a modern school building.

"The problem of seeing in the classroom is a major one. Recent research has shown that children's eye defects increase steadily from a low percentage in the early grades to an alarmingly high ratio in the upper grades. It further shows that poor visual conditions definitely have harmful effects on posture, on nutrition, and on learning rates. It is also evident from research that the provision of better visual conditions will decrease eye defects and improve other factors (30)."

"School lighting is much more than glass area and wattage. It is fundamentally a matter of brightness balance of natural and artificial light sources and reflecting surfaces within the total visual environment. Although the eye adjusts readily to its environment, it cannot adjust to excessive brightness differences which exist simultaneously within the visual field. Such conditions result in eye strain and lowered efficiency. Brightness differences can be reduced by shielding the lamp, seating the pupils so they will not face the windows, repainting with pastel tints, using lighter furniture and chalk board, and increasing the light intensity within the room (31)."

30. "Seeing in the Classroom," by Wilfred F. Clapp, chief, Division of School Plant, Department of Public Instruction, Michigan. Published by Eugene B. Elliott, Superintendent of Public Instruction, 1947 Page 1
"Light is something more than a means for aiding the child in the recognition of words and objects. It is a force in his environment, and an important one - a force that can shape or distort the total child, his eyes, his muscles, his well-being, currently or permanently (32)."

1. DEFINITION OF TERMS

Footcandle - the illumination produced at a surface, all points of which are at a distance of one foot from a uniform point source of one candle.

Reflection factor - the percentage of the total amount of light falling upon a surface which is reflected by that surface.

Footlambert - the brightness of the surface upon which the light falls, a brightness of one candle per square inch is equal to 452 foot-lamberts.

Brightness - the luminous intensity of any surface which may be created either by reflection or direct transmission of light.

Surrounding field - extends 30 degrees on each side of the line of sight, thus forming a total area of approximately 60 degrees in the center of the total visual field.

Peripheral field - that area outside the surrounding field and included in an area approximately 120 degrees vertically and 160 degrees horizontally, centering on the line of sight.

32. "Light on the Growing Children," Dr. Darell B. Harmon, Director, Division of Educational Services, Texas State Department of Health. Architectural Record, Volume 99, Number 2, February 1946 Page 79. Published by F. W. Dodge Corporation, Concord, New Hampshire
2. **QUANTITY OF LIGHT**

The quantity of light is measured in terms of footcandles on the working surface. There is still no reliable data as to the amount of illumination required for different types of work; the recommendations for classroom work varies from five to five-hundred footcandles. The recommendations of The Illuminating Engineering Society are generally followed by most architects.

**LIGHTING INTENSITIES RECOMMENDED BY THE ILLUMINATING ENGINEERING SOCIETY**

<table>
<thead>
<tr>
<th>AREAS</th>
<th>FOOTCANDLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms and libraries</td>
<td>30</td>
</tr>
<tr>
<td>Sight-saving classroom</td>
<td>50</td>
</tr>
<tr>
<td>Auditoriums, cafeterias and rooms</td>
<td>10</td>
</tr>
<tr>
<td>not used for study</td>
<td></td>
</tr>
<tr>
<td>Reception rooms, locker rooms, washrooms, stairways, etc.</td>
<td>10</td>
</tr>
<tr>
<td>Corridors and storerooms</td>
<td>5</td>
</tr>
</tbody>
</table>

**RELATIVE AMOUNTS OF LIGHT NEEDED FOR CERTAIN VISUAL TASKS**

<table>
<thead>
<tr>
<th>VISUAL TASKS</th>
<th>8-POINT BODONI BOOK TYPE</th>
<th>8-POINT BODONI BOOK TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading 12-point Bodoni Book Type</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Reading 8-point Bodoni Book Type</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Reading one's own handwriting in pencil</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Reading newspaper text</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Booking</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>Drafting</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Business</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Sewing with white thread on white cloth</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>Using steel scale with 1/64th-inch divisions</td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>Sewing with black thread on black cloth</td>
<td>42.0</td>
<td></td>
</tr>
<tr>
<td>Precision die making</td>
<td>70.0</td>
<td></td>
</tr>
</tbody>
</table>

"The foregoing comparisons illustrate the fact that quantity of light needed depends on the task to be accomplished, but they
obviously cannot serve as a guide to the relative differences in light levels to be maintained in schoolrooms. Reasonably high general levels of illumination, from 20 to 40 footcandles in ordinary class rooms and 50 or more in class rooms where seeing tasks are unusually difficult, can be supplemented by local task lighting to improve visibility for especially critical tasks of seeing (33)."

3. QUALITY OF LIGHTING

To attain ideal seeing conditions, the brightness ratio of the visual task to its immediate surroundings is unity, and the brightness ratio of a light source or of a luminous portion of a luminaire to its background is unity. In a practical sense the attainment of these conditions is virtually impossible. The Illuminating Engineering Society recommends that brightness ratio to attain good seeing conditions should be not greater than three. According to literature examined there is agreement on two conditions: (1) within the surrounding field the brightness difference should not be more than ten times nor less than one-fifth the brightness of the visual task, and (2) within the peripheral field the brightness difference should not be more than fifty times nor less than one-fifth the brightness of the visual task. There is also agreement on the reflection factor for different surfaces as shown in the following table:

33. Supra (17) Pages 224-226
REFLECTION FACTORS RECOMMENDED FOR DIFFERENT SURFACES IN A CLASS ROOM

<table>
<thead>
<tr>
<th>SURFACES</th>
<th>REFLECTION FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>85%</td>
</tr>
<tr>
<td>Walls</td>
<td>60%</td>
</tr>
<tr>
<td>Floors</td>
<td>30-40%</td>
</tr>
<tr>
<td>Chalk board (light green)</td>
<td>20%</td>
</tr>
<tr>
<td>Equipment</td>
<td>30-40%</td>
</tr>
</tbody>
</table>

Although these recommendations are based on the observations of specialists, they are arbitrary and tentative. Present and future research may produce results that will change the areas of the visual field and brightness-differences for more eye comfort and efficiency.

Quality depends on the location of the light and its intensity, and the environment or surroundings of the light, including color, brightness, and reflection factors, as shown above, of the ceiling, walls, floor, and furniture. Good quality light cannot be obtained where extreme brightness-differences exist.

"The foot-lambert figures given below are average values for some of the brightness found in class rooms. Variable factors will cause actual readings for some of the items listed to be considerably higher or lower. Notice the reduced ceiling brightness made possible by a longer hanger stem on the reflector."
ILLUSTRATIONS OF BRIGHTNESS (34)

FOOTLAMBERTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Footlamberts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear sky</td>
<td>1,000</td>
</tr>
<tr>
<td>Hazy sky</td>
<td>2,000</td>
</tr>
<tr>
<td>White clouds</td>
<td>3-5,000</td>
</tr>
<tr>
<td>Sunlight on white buildings</td>
<td>8,000</td>
</tr>
<tr>
<td>Sunlight on trees</td>
<td>320</td>
</tr>
<tr>
<td>Bare 200-watt filament bulb</td>
<td>65,000</td>
</tr>
<tr>
<td>Enclosing globe</td>
<td>1,200</td>
</tr>
<tr>
<td>Bare fluorescent lamps (48&quot;) At 90-degree angle to axis</td>
<td>1,900</td>
</tr>
<tr>
<td>At 30-degree angle to axis</td>
<td>1,400</td>
</tr>
<tr>
<td>Shielded fixture</td>
<td>500</td>
</tr>
<tr>
<td>White ceiling above indirect fixture</td>
<td></td>
</tr>
<tr>
<td>500-watt hung 30&quot; from ceiling</td>
<td>75</td>
</tr>
<tr>
<td>500-watt hung 48&quot; from ceiling</td>
<td>45</td>
</tr>
<tr>
<td>750-watt hung 48&quot; from the ceiling</td>
<td>65</td>
</tr>
<tr>
<td>Blackboard with 25 F. C. (10% R.F.)</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Color and finish also play an important part in the lighting conditions within a room. Color determines the reflection factor or brightness of a surface while finish determines the glare factor. Ray L. Hamon in "Lighting Schoolrooms," gives 500 foot-lamberts as the maximum brightness and fifteen as the maximum glare factor for satisfactory visual environment of schoolrooms. A dark color will naturally reflect less light than a light color, and a dull surface will have a smaller glare factor than a glossy surface. The following table gives some idea of the reflection-factors of different colors.
### Approximate Reflection Factors for Colors (35)

<table>
<thead>
<tr>
<th>Colors</th>
<th>Factors</th>
<th>Colors</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>83%</td>
<td>Tan</td>
<td>50-30%</td>
</tr>
<tr>
<td>Gray</td>
<td>70-44%</td>
<td>Brown</td>
<td>40-20%</td>
</tr>
<tr>
<td>French gray</td>
<td>40%</td>
<td>Green</td>
<td>55-20%</td>
</tr>
<tr>
<td>Dark gray</td>
<td>19%</td>
<td>Olive green</td>
<td>20%</td>
</tr>
<tr>
<td>Ivory white</td>
<td>80%</td>
<td>Azure blue</td>
<td>55%</td>
</tr>
<tr>
<td>Caen stone</td>
<td>78%</td>
<td>Sky blue</td>
<td>37%</td>
</tr>
<tr>
<td>Ivory</td>
<td>71-63%</td>
<td>Shell pink</td>
<td>54%</td>
</tr>
<tr>
<td>Pearl gray</td>
<td>73%</td>
<td>Pink</td>
<td>70-50%</td>
</tr>
<tr>
<td>Buff</td>
<td>70-40%</td>
<td>Cardinal red</td>
<td>20%</td>
</tr>
<tr>
<td>Buff stone</td>
<td>20%</td>
<td>Red</td>
<td>40-15%</td>
</tr>
</tbody>
</table>

4. **Artificial Illumination**

There are many ways of providing artificial light in a classroom. Incandescent or fluorescent luminaries may be used either as direct, semi-direct, semi-indirect, or indirect sources of light in many different arrangements. Variables which would influence the choice of one scheme of artificial lighting over another are: initial cost, operating cost, efficiency, desired results, cleaning, and maintenance. One precaution which must be taken is to prevent a source of direct light from entering the pupils' line of vision. Artificial illumination shall be considered a supplement to natural lighting only on dark, cloudy days and when necessary shall be capable of providing the required illumination independent of natural sources. For best results, an illuminating engineer should be consulted or engaged to design the lighting system.
There appears to be no one best classroom model for natural lighting, but there are sufficient designs for certain combinations of climate, orientation, building plan, and height, artificial illumination system, and educational program. Some schools built during the war-restricted period with no wiring, are said to have given satisfactory performance the year round in southern climates by virtue of well calculated design. The following paragraphs describe several of the natural lighting schemes, both unilateral and bilateral, investigated by Douglas Haskell (35) (Sketches pages -)

**SCHEME A** - The sloped ceiling and louvered awning scheme reported on by Prof. Leland Brown produced the highest levels of illumination encountered in the survey. The inmost rows of desks received 44 percent as much light as the window rows. The brightness range was relatively one of the lowest. Contributing factors were the open surroundings, high ceiling at the windows, reflecting slope, high proportion of glass, pipe mullions and windows shaded by open louvered canopy. Another version with a second slope at the rear of the room proved unnecessary, but the use of venetian blinds with ceiling pocket storage was considered a good idea because it permits simple manipulation and fixed louvers, assuring maximum reflection efficiency.

35. "16 Ways of Daylighting Classrooms," by Douglas Haskell, Associate Editor, Architectural Record, Volume 95, Number 5, May 1944. Published by F. W. Dodge Corporation, Stroudsburg, Pennsylvania. Concord, New Hampshire
The directional glass block scheme reported on, like other unilateral schemes, is adapted to plans with central corridors, also to more than one story. The glass block reflects the light to a sloping ceiling which at the rear of the room, is quite low. The prisms in directional glass block diffuse the reflected light between a horizontal line and a vertical line and, for this reason, should not be used below eye level. Directional glass block sends more light to the rear of the room. Clear glass sashes beneath the block give the seated children a good view and are provided with roller shades for the short daily periods of direct sunlight to the outermost row of desks. Dr. Harmon, in his experiments, found that this scheme gave the most desirable results of the four rooms in the test (36). The ratio of light intensities was less than eight to one, and the brightness ratio between the upper part of the glass block panel and the upper part of the inside wall was less than five to one.

This is a modification of Scheme A, turning the vulnerable side of the building toward the south for solar heating. Despite the southern exposure, no direct light enters the room. The louvered canopy protects the lower panel of windows, and the diagonal position of the upper panel of louvers increases efficiency by throwing light to the back of the room.

36. Supra (32)
SCHEME D - This bilateral scheme has a level ceiling and a solid roof projection, with a concealed roller for the canvas shade, shading the larger windows. With the southeast orientation an even distribution of illumination was obtained, but this was accompanied by an excessive brightness range. When the solid canvas shade was lowered the evenness of illumination became almost perfect, while the intensity was lower but still acceptable.

SCHEME E - This bilateral scheme incorporates a slope upward toward the transom windows instead of toward the main windows. The combination of high large transom windows and the slope are such that, with correct adjustment of the venetian blinds, almost shadow-free illumination is provided, and the illumination curve is remarkably level. A louvered canopy above the larger windows might be an improvement over the solid type of overhang and the canvas shade shown here. A similar scheme is used in a northern location with both the main windows and the transom windows smaller. In this scheme the venetian blinds over the transom windows are eliminated and the corridor roof faced with white asbestos to act as an exterior reflector.

These are a few of the many possible natural lighting schemes which have been used in contemporary school design to provide adequate, if not perfect, natural lighting in school
rooms. Other clerestory and skylight schemes have been used but with more complicated roof construction which naturally increases the cost of building.

Scheme B and Scheme E are combined in the design of the elementary school proposed in this thesis to give a maximum brightness and an even distribution of illumination over the entire room. The roller shade in Scheme B is replaced with a two foot canopy to eliminate manipulation of the shades by the teacher. The corridor roof on the north side has a white asbestos surface to reflect the north light through the clerestory windows to the ceiling of the room.
VI

THE DESIGN
THE DESIGN

1. PROGRAM:

The program for the proposed school was formulated on the basis of a report printed for the Roanoke School Board after a survey was made of conditions and needs which resulted in the present school building program. The maximum number of students to be housed by the Grandin Court Elementary School has been estimated to be three hundred and sixty. The prescribed maximum of thirty students per class makes twelve classrooms a necessary minimum. The use of standard areas per pupil determines the size of the various other units and in some cases the areas were increased to allow for community use.

2. SITE:

The site used in the solution of the design was purchased by the Roanoke School Board as the future site of Grandin Court Elementary School. This site is ideally located in relation to the area which the school is to serve and has more than the necessary area for the maximum number of students, but the general topography is not very suitable for school use. Except for a small area on the south side and a narrow strip along the east border which have a gentle slope of less than ten percent, there is a general slope away from a point near the center of the plot of twenty percent or more. The south
slope was selected as the building site for orientation, protection from the prevailing winds, and ease of access. This allows a general classroom orientation toward the south for almost uniform lighting throughout the class hours and utilization of the corridors as insulation against the northern cold. The grove of trees along the top of the hill also serves as protection from the northern cold and from the prevailing winds. The small area with the gentle slope is utilized for the administration unit and for a level play court for the primary classes. The east and north-east portion of the lot is graded to form two level areas for organized games and a gentle slope for small games. A small area on the north slope is leveled and protected by a retaining wall for play equipment, such as swings and slides, as is also a smaller area on the west slope. The west and northwest slopes are turfed and planted with trees to be used as a park and picnic area and for the location of a small amphitheater.

3. PLANNING

As previously stated the south slope was chosen as the building site and the administration unit and the primary unit of four classrooms placed on the gentle slope. Two units of four classrooms each are placed on two levels to the west in a stepped arrangement. Also to the west, on a lower level, is the cafeteria unit adjoining the combination service and
teachers' parking area, which offers easy access to the street. This area also serves the heating room and the storage and shop area under the adjacent classroom wing. The general purpose room is on the east, adjacent to the play area and with a direct approach and entrance for community use. A room for bicycle racks is provided under the teachers' lounge and convenient to the student entrance. An entrance is provided for the teachers and staff to the rear of the students' lobby and convenient to the parking area. A public entrance and lobby, secondary to the student entrance, is adjacent to the administration unit and to the library. All units are connected by main corridors, well lighted and ventilated by strip windows giving good views of the courts and surrounding scenery.

The planning of the individual units includes all points mentioned in the previous section, Analysis of School Planning. In addition each classroom has been planned for the use of audio-visual equipment and each classroom wing is provided with a small room for preparation and storage of film, slides, and equipment. A part of the work room is also used for this purpose.

4. ESTHETICS

No artificial decorations have been applied to the building and the esthetic appeal of the building is dependent upon the use of materials, proportion of the masses, and landscaping
and natural conditions of the site. The classroom and administration units present a horizontal pattern; the masonry base is topped by a narrow strip of clear glass and this in turn is topped by a strip of directional glass block. The public entrance is intentionally smaller than the student entrance so there is no conflict between the two.
VII

MATERIALS AND CONSTRUCTION
MATERIAL AND CONSTRUCTION

1. ROOF:

Built-up roofing is applied to a concrete slab reinforced with expanded metal. The roof slab is supported on bar joists - light solid joists are used over the corridors, which in turn are supported by roof beams. Acoustical-tile, applied to wood strips, is hung from the bar joist and supports rock wool insulation. The edge of the roof is finished with a wood facia.

2. WALLS:

The roof supports of the classrooms and administration unit are light weight steel I-sections placed behind alternate window mullions. These I-sections carry through from the foundation to the roof beams on the south side, and the steel channel sections used for lateral support also carry the weight of the glass block above. A non-load-bearing cavity wall, faced with brick and backed with cinder brick, is below the windows. The corridor partitions and outside walls are load-bearing and carry the weight of the roof from short I-sections to the foundation. Free standing pipe columns support the roof over the cafeteria and general purpose rooms. These rooms have non-load-bearing cavity walls on the sides, and the end walls are load-bearing. All windows are the projected steel type.
3. **PARTITIONS:**

All partitions in the classroom and administration units are semi-permanent cinder block faced with aoustical tile on exposed surfaces. Some of the partitions in the administration and library units are partially clear glass for light and openness.

4. **FLOORS:**

All floors, except the basement floors, are reinforced concrete slab and beams with the under surface faced with a reflecting material. Asphalt tile is used as the surface in all areas except the corridors, lobbies, general purpose room, toilets, and other wet areas. These areas are surfaced with terrazza except the general purpose room, which has a hard wood surface. The basement floors are reinforced concrete slab on gravel fill and the surface is glaze finished for ease of cleaning.
VIII

CONCLUSION
CONCLUSION

Public education is slowly gaining its rightful place in the minds of the general public and of the officials and administrators of our national and local governments, but it is a difficult task to convince everyone that a good educational system is a very important factor in the national welfare and social progress, deserving the same attention as other major national institutions. General trends in education are to teach, or to familiarize the student with a greater variety of subjects, some of which have previously been taught in the home or entirely left out of the child's educational training. This necessitates the construction of more elaborate and costly school facilities than have been built in the past.

It is evident, after studying the site purchased for the school proposed in this thesis, that it is of the utmost importance that the architect be consulted before school sites are purchased. There are two choices in preparing the site for the building: one is to do a great deal of grading for a compact building unit, and the other is to take advantage of the natural slopes for a spread plan and give good views of the surrounding natural beauty. It is estimated that either of these approaches would involve about the same expense, so the second choice is made to give a pleasing design and a functional plan.
IX

PRESENTATION
PERSPECTIVE OF ENTRANCE
AN ELEMENTARY SCHOOL

FOR ROANOKE VIRGINIA
PERСПЕКТИВЕ OF SCHOOL
VIEW OF MODEL OF EXISTING SITE FROM ABOVE
VIEW OF MODEL OF EXISTING SITE FROM SOUTHEAST
SITE DEVELOPMENT
PLANS OF TYPICAL CLASSROOMS
FRONT ELEVATION AND SECTIONS
TYPICAL CLASSROOM SECTION AND DETAILS
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BIBLIOGRAPHY

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