GUIDELINES FOR DEVELOPING TYPE DESIGNS FOR SCHOOL BUILDINGS IN NEPAL

This document presents the recommended procedures to be used for the development of Type Designs for new school buildings for Post-Earthquake Reconstruction of education facilities.

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Asian Development Bank

Department of Education (DOE)
Ministry of Education
Government of Nepal

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Several individuals and organizations have contributed towards the development of these guidelines, including Dr. Naveed Anwar, Asian Institute of Technology, Post Disaster Management Consultant, ADB as the coordinating author, and contribution and feedback by Ar. Ujjwal Man Shakya, Architecture Consultant, ADB, Er. Udhab Nepal, Department of Education (DOE), MOE, Dr. Youb Raj Paudyal, DOE, MOE, Dr. Tomohiro Shitara, Consultant, JICA, Ar. Timothy Stats, Infrastructure Specialist, Australian Civilian Corps, Ms. Judy Oglethorpe, World Wide Fund for Nature. Special thanks to the assistance extended by ADB NRM through Ms. Smita Gyawali, Project Officer (Education) for the development of the guidelines.

Contents

List of Figures

List of Tables

List of Abbreviations

ACI	American Concrete Institute
ADB	Asian Development Bank
AIT	Asian Institute of Technology
BOQ	Bill of Quantity
DOE	Department of Education
DRM	Disaster Risk Management
DR	Disaster Resilience
DUDBC	Department of Urban Development & Building Construction
ES	Environmental Sustainability
EMIS	Education Management Information System
GON	Government of Nepal
HFA	Hyogo Framework for Action
INGO	International Non-governmental Organization
IS	Indian Standard
JICA	Japan International Cooperation Agency
MOE	Ministry of Education
MOH	Ministry of Health
NGO	Non-governmental Organization
NRRC	Nepal Risk Reduction Consortium
NSET	National Society for Earthquake Technology - Nepal
PDNA	Post Disaster Needs Assessments
RC	Reinforced Concrete
SSP	School Safety Program
SMC	School Management Committee
SSRP	School Sector Reform Program
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
VDCs	Village Development Committees
WB	World Bank

Chapter 1 Introduction

1.1 Overview

A major earthquake of shallow depth measuring 7.6 on the Richter scale struck central Nepal on April 25th causing widespread destruction. There have been several aftershocks, including a significant one measuring 6.8 on May 12 causing further causalities and damage

The Government of Nepal (GoN), and several development partners have developed a comprehensive Post Disaster Need Assessment (PDNA) document. Within the education sector, the PDNA identifies the needs for rehabilitation and reconstruction of affected infrastructure such as school buildings and facilities. After the disaster, a draft plan was approved for the reconstruction of educational sectors, addressing both short term and long-term reconstruction, along with the overall agenda of "built back better".

The draft plan approach for the reconstruction of schools requires reconstructed schools to be designed as:

1 An integrated school facility, using the integrated approach for considering the learning environment, child friendly, multi-hazard disaster resilience, and environmental sustainability, attention to special needs, gender and ethnic consideration

2 Using appropriate technologies, consistent with geoclimatic location, local materials, technologies etc.

For applying this strategy to a very large number of schools, in a short time, it is necessary to standardize the design and details, so that consistency and up scaling can be achieved. A number of type designs will be produced to suit to a range of contexts; following are guidelines in developing the type designs:

1.2 Scope and Purpose

This document is intended to provide overall guidelines for developing the type design for various types of school buildings, facilities and related physical infrastructure for schools in affected districts.

The recommendations in this document are primarily developed for the "Post-Earthquake School Reconstruction Project", as a follow-up of the Post Disaster Need Assessment (PDNA).

The document is prepared based on the review of the following documents, as well as the local practices, and the interaction with various stake holders in the current project.

1. UNESCO's Educational Building & Furniture Programme, July 1989
2. Time Saver Standards, TSS
3. Department of Education, Nepal (Type Designs AutoCAD files)
4. Nepal National Building Codes including NBC 206: 2003 Architectural Design Requirements; NBC 105: 1994 Seismic Design of Buildings in Nepal; NBC 107: 1994 Provisional Recommendation on Fire Safety; NBC 108: 1994

Site Consideration for Seismic Hazards; NBC 2008: 2003 Sanitary and Plumbing Design Requirement and others

5. Related research papers, standards and reports

1.3 Philosophy and Principles

As funds, time and resources are limited; they need to be "well spent". The Type designs need to be developed to strike a balance between high functionality and cost effectiveness. The provisions and guidelines in this document are based on good, acceptable norms, compared to above standards, as will as in keeping with the local context of Nepal.

The type designs represent the minimum requirements; it is understood that some "Model Schools" are also planned as part of the re-construction process, and those will be based on higher standards than type designs, with more liberal spaces and greater range of facilities.

1.4 Definition of "Type Design"

The "Type Design" in the present context is used to define functional, architectural, structural, and infrastructure design of standard new school buildings to be constructed for post-earthquake reconstruction in 14 most affected districts. Whilst reconstruction of each school facility will need to respond to unique design challenges, the type designs are intended to serve the most common combination of needs, covering at least 80% of the cases. They can also be considered to cover all other districts in the country according to the overall agenda of "Build Back Better". For remaining schools, specific design need to be developed, using the provisions of this document as overall guiding principles.

The types designs include standardization and a modular approach to be used at all stages of planning, design, detailing and construction. Only in exceptional cases deviation from the standard modules should be allows. This standardization and modularization will help to reduce cost, improve quality, facilitate efficient supervision and monitoring, and quality control etc., including:

- Modular sizing and layout of classrooms
- Modular sizing and layout of buildings
- Modular dimensions for most of the building components such as doors, windows, fittings, fixtures, and even size of panels, bricks/blocks etc.

1.5 Key Considerations

The key considerations for developing the type design are:

1. Identification of the needs to be met
2. Architectural and Space Planning Requirements
3. Integrated DR and ES considerations
4. Child, gender and differently–abled (CGD) friendly considerations
5. Materials and Construction Technology considerations
6. Structural Design considerations

7. Site Infrastructure and Landscape Design considerations
8. Basic landscape design considerations
9. Climate smart design considerations

Chapter 2 Identification of the Needs

2.1 Overview

It is important that the Type Design of the school buildings be developed in such a way that they serve the needs of the most common cases amongst the schools to be rebuilt.

2.2 Design Student Number

One of the most important parameters affecting the size of the school building and facility is the target number of students to be served, or the Design Student Number. (DSN). A simple statistical analysis and generation of histograms of the actual enrolment of the students in the schools to be re-built should be carried out to determine the target DSN. The school building can then be rated for the preferred minimum and maximum number of students. This range may be termed as the Applicable Student Range (ASR).

While computing the DSN and the ASR, due consideration should be given to the actual number of classes to be run in a particular school type and typical number of students within each class, in addition to the total number of students in the whole school. The histograms of the number of students in various grades may be used to design classrooms more optimally, rather than using same classroom size for all levels.

Adjoining classrooms of smaller size may be designed in such a way that they can be combined to create bigger spaces as needed, depending upon size of school. These should be defined with close consultation with DOE. However, mostly the classroom size should be of same standard size.

2.3 Classroom Size Categorization

Sizes of the classrooms should be based on the number of students and the unit space required per student. On this basis the standard modules/materials/furniture sizes within the classroom can be rounded up or down to be utilized in more practical and cost effective way. However, for the purpose of area estimation, an average of 0.9 sq. m per student is recommended for Primary Schools with an absolute minimum of 0.75 sq. m required per student. For Secondary Schools 1.2 sq. m per student is recommended whilst the absolute minimum required is 1.0 sq. m per student[1].

Histograms of various student numbers for different school types, grades etc. are generated to arrive at the appropriate needs and classification (refer Appendix A.)

[1] Education Rules, 2059 (2002)

Table 2-1 Room Size Categories

Room Size Categories

Room Type	Number of Students			Suitable For Grades	Nominal Area (Sq. M)
	Design	Minimum	Maximum		
RP1	12	5	15	G 1-5	12
RP2	25	20	30	G 1-5	25
RP3	40	30	45	G 1-5	40
RS1	25	20	35	G 6-12	35
RS2	40	30	45	G 6-12	45
RS3	60	40	70	G 6-12	70

RP1 = Room for Primary Schools- Type-1

RP2 = Room for Primary Schools-Type-2

RP3 = Room for Primary Schools-Type-3

RS1 = Room for Secondary School- Type-1

RS2 = Room for Secondary School- Type-2

RS3 = Room for Secondary School- Type-3

For example: RP2 illustrates the room of a primary school categorized in Type-2, designed for 25 students/classroom. It can be arranged from 20-30 students/classrooms. The classroom size is 25 sq.m. The room size type RP3 and RS3, could either be a large lecture theater, or may be replaced by 2 class rooms of type RS2, depending on availability of teachers and organization of the school class structure.

2.4 School Size Categorization

The school size categorization is based on the number of students enrolled in schools for various types in the 14 most affected districts. The type designs are selected to cover at least 80% of schools to be reconstructed.

For Higher Secondary School (HSS), some schools are found to be very large, with over 900 students (purple shade). Although the basic planning for such schools can be done based on the recommendations in these guidelines, such schools may be designed as individual cases, considering specific needs of the site, location, district, student and class distribution etc.

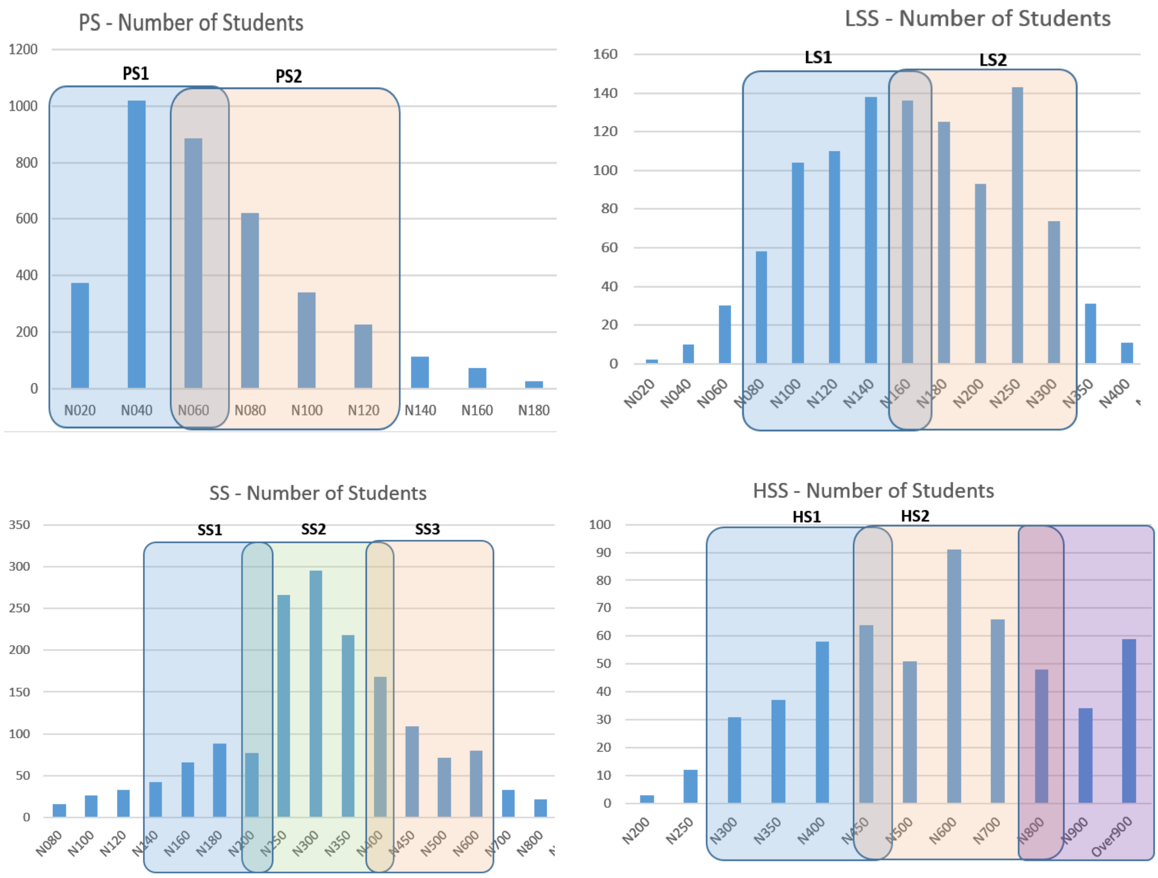


Figure 2-1 Distribution of number of students in various schools by level

Table 2-2 School Type and Room Size Combination

School Type	Type Code	Design Student Nos.	Number		Possible Room Combination	Provided Student Capacity
			Grade	Rooms		
Primary-1	TD-PS1	40	5	4	4RP1	48
Primary-2	TD-PS2	90	5	4	4RP2	100
Lower Secondary-1	TD-LS1	140	8	8	8RS1	200
Lower Secondary-2	RD-LS2	220	8	8	4RS1+2RS2+2RS3	300
Secondary-1	TD-SS1	160	10	10	6RS1+2RS2+2RS3	350
Secondary-2	TD-SS2	300	10	10	4RS1+3RS2+3RS3	400
Secondary-3	TD-SS3	480	10	14	6RS1+4RS2+4RS3	550
Higher Secondary-1	TD-HS1	400	12	12	4RS1+4RS2+4RS3	500
Higher Secondary-2	TD-HS2	600	12	16	6RS1+5RS2+5RS3	650

2.5 Overall Facilities to be provided

The list and recommended sizes of various facilities, in addition to the basic classrooms is provided below for consideration of the type design for various schools.

Table 2-3 Type Design Requirements for various schools

School Type	Primary		Lower Secondary		Secondary			Higher Secondary	
Type Code	TD-PS1	TD-PS2	TD-LS1	RD-LS2	TD-SS1	TD-SS2	TD-SS3	TD-HS1	TD-HS2
Grade	5	5	8	8	10	10	10	12	12
Design Capacity (Students)	40	90	140	220	160	300	480	400	600
Number of Floors	Depends upon type of geographical location i.e for rural and semi rural upto 2 stories and for urban upto 3 stories								
Labs and other Facilities Area (Sq. m)									
Library	30	40	50	60	50	70	90	90	120
Music	30	40	30	60	30	50	60	60	80
Drawing									
Computer			30	60	30	60	90	90	120
Physics			40	60	40	50	60	60	90
Chemistry					40	50	60	60	90
Biology					40	50	60	60	90
Multipurpose					80	100	120	120	150
Offices Area (Sq. m)									
Head Master	20	25	15	15	20	20	20	25	25
Teachers			30	40	40	50	60	50	90
Admin						15	15	15	25
Store	20	25	20	20	30	40	40	40	50
Kitchen			20	30	30	30	40	40	50
Boys Toilet Facilities									
Urinals	1	2	3	5	4	7	12	10	15
WC	1	1	1	2	2	3	6	5	7
Wash Basins	1	1	1	1	1	2	4	3	5
Girls Toilet Facilities									
WC	1	1	2	4	3	6	9	8	12
Wash Basins	1	1	1	2	2	3	6	5	7
Other Facilities									
Water Fountains	1	1	2	4	3	6	9	8	12
First Aid/Clinic	<N1>	<N1>	<N2>	<N2>	<N2>	<N3>	<N3>	<N3>	<N3>
Fire Safety									
Circulation									
Stairways width, m			2	2.0 to 2.5	2.0 to 2.5	2.0 to 2.5	2.0 to 2.5	2.0 to 2.5	2.0 to 2.5
Stairway numbers			1	2	2	2	3	3	4
Single loaded corridors, m	1.8	1.8 to 2.5	1.8 to 2.5	1.8 to 2.5	1.8 to 3	1.8 to 3	1.8 to 3	1.8 to 3	1.8 to 3
Double loaded corridors, m			2 to 3	2 to 3	2.4 to 3.5	2.4 to 3.5	2.4 to 3.5	2.4 to 3.5	2.4 to 3.5
Min. open assembly space, Sq. m	60	135	210	330	240	450	720	600	900

N1 A cupboard with first aid kits to be provided in the library

N2 A cupboard with first aid kits to be provided in the library and labs

N3 A cupboard with first aid kits to be provided in labs, a separate counter with a nurse is preferred

Note:

First aid kit is required at every school. For larger regional schools or those particularly isolated, consider a dedicated emergency facility with dual purpose to a) help in the immediate response to disasters (e.g.: first aid, basic search and rescue equip., shovels, ropes, firefighting equipment, etc. a and b) assist if the school was to be used as a post-disaster collection / refuge center. This could mean the provision of additional toilets beyond what student numbers would dictate, blankets, emergency food and water etc. The SMC and relevant DEO need to consider broader implications of this in terms of budgeting for upkeep and maintenance and ensuring community members are trained to use the equipment.

Chapter 3 Architectural and Space Planning Requirements

3.1 Overview

This chapter describes the preferred space planning guidelines for application to design of typical school buildings. However, the architects and engineers should also consider the relevant provisions of the national building codes of Nepal, and apply these recommendations, appropriately, and in case of any conflict, obtain clarifications and consent of relevant administrative bodies such as DUDBC,

3.2 Space Allocation

3.2.1 Classroom Sizing

1 The width to length ratio for classroom and learning spaces should have comfortable usage, which should be in between 1:1 and 1:2 and have flexible use of the space. Attention should be paid to achieve good teacher – student interaction. Classroom ratio should also focus upon preventing tendency of students to choose backbench.

2 Maximum distance between black board/white board and Last row of benches is 7 m and minimum distance between black board/white board and the first row of benches is 2 m.

3 Corridor as exit medium should be calculated using exit medium formula, minimum of 1.5 m clear in width excluding any storage/lockers etc. According to flow of traffic, the width of circulation areas should increase to avoid circulation bottlenecks.

4 Ceiling height depends on space usage and physical environment within the space and geo-climatic condition. Minimum floor to ceiling height should be 2.75 m in hill/mountain belt and 3.6 m in terai belt, taking into account an even distribution of natural light and natural ventilation across the whole floor area of the room.

5 All the rooms and facilities should have visibility, so that the pupils can have protection from abuse by teacher or older student, particularly during after-school hours.

3.2.2 Access

6 All new school buildings and new extensions should be designed so as to provide equal access for all including people with special need at least at ground floor.

7 Building should have suitable emergency and fire exit.

8 As per NBC 206 , stairs with 2 or more risers need to have minimum clear width (unobstructed by projection or handrails) of 2,000mm. Further details are contained within the Code.

9 Maximum travel distance to exits shall not exceed 30m (NBC 107).

3.2.3 Multi-stories

10 Schools in rural areas may be a maximum of 2 stories. In urban areas schools may be a maximum of 3 stories. Within the Kathmandu Valley, schools may be up to 5 stories

3.2.4 Classroom Size and Space

11 Sizes of the classrooms should be based on number of students/ classroom and unit space required per student of specific grades (determined from statistical analysis) rather than on arbitrary rules on unit areas per student etc. Refer to section 2.3 of these guidelines for more details.

12 Classrooms can vary in size and serve different functions, with children moving from one to another for different purposes.

13 Classroom should also allow for a number of different activities, such as reading, research, group work and art.

14 Classroom should have direct access to the outdoor for multiple learning opportunities and should have intermediate spaces (e.g., corridors as exit route) in between.

15 Classroom furniture layout should be considered to have a number of flexible layout options.

16 The orientation of classrooms and their location relative to the development of the external environment must be considered by the Design Team in the planning of the building.

17 Doors as exit medium should be easy to open and close. Care should be taken in the design of the door; frame, and opening mechanism to eliminate injury to fingers etc., and adequate vision panels for small children should be considered. Two doors shall be provided if the number of occupants in the room is greater than 50. Consider a single vision panel covering a vertical zone between 500mm and 1500mm from the floor, or two vision panels, the lower of which at least covers a vertical zone between 500mm and 800mm from the floor and the upper of which at least covers a vertical zone between 1150mm and 1500mm from the floor. Glazing should be toughened and provide fire, security and acoustic separation as far as possible).

18 To facilitate emergency exit, all doors should open outwards towards the nearest exit and at least one door need to make wider for easy access for wheel chair. Size of the door and windows depend on the geographical location as well

19 Consideration should be to given to avoid square or sharp edges at heights where they would pose a hazard to movement of children in the facility.

20 Natural day lighting should be exploited when designing rooms to minimize the dependence on artificial lighting. Glare must be avoided while looking at blackboard from each and every seat.

21 Minimum area of openings for natural light 1/10th of the room area and Where possible, north facing windows should be preferred to increase diffuse light.

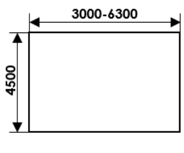
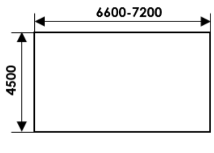
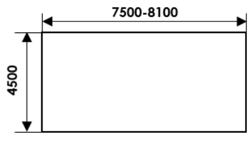
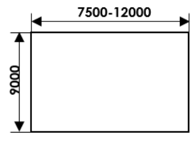
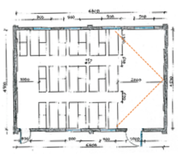
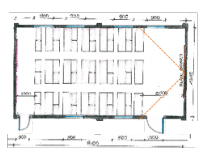
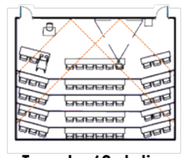
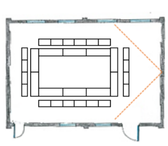
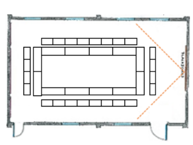
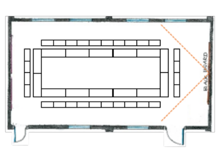
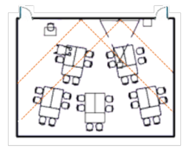
22 The positions of black-boards; white and green boards, and pin boards should be well determined at design stage and the location of surface mounted services should not conflict with the position of these boards.

23 Lighting provision within each room shall be functional with switching provision allowing for separate control of perimeter lighting.

24 Illumination level of various rooms of school should meet Nepal Building Code NBC 207: 2003 Electrical Design Requirements.

The classroom standards suitable for Secondary Schools Nepal can be referred from following table:

Table 3-1Classroom Standards

Classroom Standards (Size and Number)			
Small (15-30 sq. m. – RP1) (1 to 1.5 sq. m. per student)	**Medium (30-35 sq. m. – RP2 & PS1) (1 to 1.5 sq. m. per student)**	**Large (35-45 sq. m. – PS2) (1 to 1.5 sq. m. per student)**	**Very Large (70-110 sq. m. – PS3) (1 to 2 sq. m. per student)**
			
 **Type I – 26 station**	 **Type I – 30 station**	 **Type I – 35 station**	 **Type I – 60 station**
 **Type II – 20 station**	 **Type II – 24 station**	 **Type II – 26 station**	 **Type II – 30 station**

(Reference: *UNICEF, UNESCO, Architect's Data, Time Saver Standard & Department of Education (DOE), Nepal)*

3.2.5 Library

25 Library is mandatory for every school with 500 or more students.

26 Minimum capacity should cater for 10% of total students at a given time with 2.4 sq.m. area per student (e.g.: 500 students means library of 120sqm internal floor space).

27 When designing the Library, due consideration should be given to the room furniture layout so as to have a number of flexible layout options.

28 The orientation of the Library and its location relative to the distribution of classrooms must be considered by the Design Team in the planning of the building.

29 Minimum floor to ceiling height should be 2.75 m in hill/mountain belt and 3.6 m in terai belt, taking into account an even distribution of natural light and natural ventilation across the whole floor area of the room.

30 Natural day lighting should be exploited when designing rooms to minimize the dependence on artificial lighting. Glare must be avoided.

31 The position and size of opening window sashes must take ease of operation into account and maintain an adequate level of safety, i.e. sashes opening dangerously over adjacent paths at ground floor level; use restrictors where necessary, etc.

32 A small separate space should be provided for repairing of books, storage of reserve books and can have space for photocopy machine. The area of this space varies according to the number of students and the size of the school.

3.2.6 Laboratory

33 The size of science laboratory should be determined as per 4 sq.m per student/classroom and others laboratory such as computer laboratory should be around 2.4 sq. m per student/classroom.

34 Laboratory should contain properly designed demonstration table for experiments carried out by the teacher.

35 Laboratory can be designed in 3 types – Fixed Layout with services in perimeters, Traditional Layout with fixed benches with all services and Island Layout with small service island, that just accommodate sink and usual services outlets

36 The laboratory should have one or several means of visual communication - chalkboard, marker board, wall charts and overhead, slide or film projectors.

37 It should have tables and sufficient space for students' practical work for the range of experiments, which the students may be expected to perform, with appropriate services required.

38 Spaces are needed for sensitive apparatus requiring special care, such as balances, radioactive materials, and their associated electrical equipment.

39 Laboratories can be dangerous places, especially chemistry labs. The following are required, with easy access, to minimize any accidents: fire extinguisher, fire blanket, eye and face spray, first aid kit, neutralizing solutions.

3.2.7 School Administration

40 The General Office should be located adjacent to the main entrance of the school, in the interests of security and control, visual and otherwise.

41 The Principal's Office should be located near the General Office but need not be accessed directly from it. It should afford the Principal a level of security and seclusion from visitors.

42 Adequate acoustic separation of the General Office and Principal's Office from adjacent rooms, circulation, etc., must be provided.

3.2.8 Teacher/Staff Room

43 The Teachers/Staff Room may be located adjacent to the Administration Area. It may also be located to overlook the play areas for supervision purposes.

44 It should be located near the reception/general office area. Members of the public should not be able to gain direct access to this room without first reporting to the reception.

45 The emphasis on the design and furniture layout is relaxation and an area with easy chairs etc., should be provided.

3.2.9 Sanitary Facilities

46 Separate toilets must be provided for boys and girls, based on the recommendations in Table 2-3

47 Toilets should be adequately and naturally ventilated to the external air directly or ducted. This shall be in addition to any open able window.

48 Lobbies to all toilets must be adequately naturally ventilated to the external air.

49 Toilets for use by the disabled should be facilitate the movement of wheelchairs and capable of accommodating a changing bench and a lifting hoist. The room should be sized accordingly.

50 Generally, there should be no need to provide separate toilet facilities for staff and teachers to ensure proper upkeep and maintenance, as well as to minimize the cost. In very large schools, separate staff toilets may be considered, which should also be available for visitors.

51 A non-slip tile floor shall be provided in all WC areas with suitable coved tile skirting.

52 Doors should be easy to open and close. They may be undercut to assist air movement. Door transfer grilles are not permitted. Care should be taken in the design of the door, frame, and opening mechanism to eliminate injury to fingers etc.

53 A disabled person's alarm shall be provided in the disabled person's toilet, comprising a pull chord with an audio unit located outside the room.

54 Within a cubicle in each block of girl's toilets, there should be provision for disposal of sanitary pad, such as an incinerator.

55 Boy's Toilet and girl's toilet should be separately located at different places within the school area.

56 The septic tanks should be located at least 30 m away from the ground water sources, and adequately design to prevent infiltration of raw sewage water into ground

3.2.9.1 Circulation and social space

57 The school main entrance area should have a strong sense of arrival and space.

58 Internal signage should be clearly visible to all users. Particular regard should be paid to signage for students with special needs.

59 All areas at ground floor level should be accessible to all building users, (excluding areas of restricted access due to security or privacy requirements).

60 Designers should make use of natural lighting, space and color in the circulation areas.

61 Floor and wall finishes should be appropriate for the school's needs and location; durable finishes should be specified.

62 If possible, draught-proof lobbies should be provided at the main entrance.

63 Stairs should have treads, risers, and balustrading in accordance to building regulations and appropriate for use by young children NBC 206.

64 The maximum travel distance to exits or stairways from any point within the single floor level shall not be more than 30 m.

65 The maximum distance doorway from any point in a passage shall be 20 m.

Chapter 4 Integrated DR and ES Considerations

4.1 Overview

It is important to consider and integrate the main considerations for the Disaster Resilience (DR) and Environmental Sustainability (ES) into the type design for the new schools. This is in line with the strategy[2] and plan [3] prepared for Nepal Education Sector in 2014.

4.2 For Disaster Resilience

The disaster resilience for various hazards should be built through integrated consideration in different steps of the school building design and construction process steps. The first step is site consideration (avoiding subsidence /filling areas, water-logged/swampy or marshy near river beds, rock falling areas, tree hazards, electric high tension line etc.).

Table 4-1various Considerations for Multi Hazard Disaster Resilience

Primary Aspect of DR	Considerations to Cover the Primary Aspect	Design and Construction Process Step
Earthquakes	If possible, avoid sites and locations known to have soil liquefaction potential during earthquakes, avoid building within a distance of 500m from the surface trace of known fault	Site selection, especially in plains of Terai, Kathmandu valley and alluvial river banks
	Select simple plan and elevation layout, and follow basic guidelines for better seismic resistance	Architectural design, structural design
	Select materials with of appropriate stiffness and ductility for walls, and primary framing members	Architectural design, structural design, material selection
	Provide proper connection details to tie-up various component of the building to provide integrity during design	Structural design, Architectural design
	Provide sufficient strength and ductility in main structural system to withstand major earthquakes without collapse or danger to life	Structural design
	Avoid use of cantilever projection serving for live load.	Architectural design
	Avoid short column effect in RC frame structure.	Structural design, Architectural design
	Connect and support non-	Architectural design

[2] Strategy for Increasing Disaster Resilience for Schools in Nepal, ADB TA 7935 NEP, 2014

[3] Overall Plan for Increasing Disaster Resilience for Schools in Nepal, ADB TA 7935 NEP, 2014

Primary Aspect of DR	Considerations to Cover the Primary Aspect	Design and Construction Process Step
	structural parts to main structural members properly to avoid "falling object" hazard during earthquake	
	Provide proper exit and evacuation paths and doors during earthquake, especially for public buildings, such as schools etc.	Architectural design
Storms and Strong Wind	If possible, avoid sites and locations in the direct path of known, regular storms	Site selection
	Avoid design or roof elements, or verandah areas susceptible to wind uplift	Architectural design
	Tie and connect all roof element to main structural members, and hold-down foundations	Structural design, architectural design
	Use wall and enclosure materials and forms to resist out of plane wind pressure	Architectural design, structural design, material selection
	Use materials that have water proof and water resistant qualities	Architectural design, material selection
	Provide windows and doors of material and form that can withstand high wind and water pressure, and provide proper connection with walls and locking system	Architectural design
	Provide sufficient strength in main structural system to withstand forces induced by high wind pressures	Structural design
	Consider the possibility of falling trees, power-lines, flying debris and its impact on the building	Site selection, architectural design, structural design
Floods	If possible, avoid sites and locations in the known, regular flood areas, and near overflowing waterways, or flash floods. As climate change advances more extreme weather events will occur, so flooding is likely to get worse. It is important to consider this issue for school sites.	Site selection
	If the building is to be located in known flood hazard, consider in basic design, by raising sleeping areas above flood level, or consider multistory living	Architectural design

Primary Aspect of DR	Considerations to Cover the Primary Aspect	Design and Construction Process Step
	Consider flood mitigation at community and locality level through diversion, storage, protection etc.	Site and Architectural planning
	Use materials that have water proof and water resistant qualities	Material selection
Fire Safety	Selection of materials and concrete cover, and fire proof coating with fire rating of at least 2 hours should be considered	Structural design and material selection
	Install basic firefighting equipment, such as fire extinguishers at all critical locations	Architectural planning
	Provide proper fire escape and exit pathways, with clear marking and specially located fire exit stairways for multistory building. Ensure that fire escape doors are not locked during school hours.	Architectural planning and school management
Lightning	Lightning protection rods, and appropriate earthing should be provided for all buildings, especially those located at hilltops, or exposed areas.	Architectural and electrical system design
Landslide	If possible, avoid sites and locations in the known, regular land slide prone areas. This is especially important after the recent earthquakes. It would be good to get sites below slopes checked out by experts for risk of future landslides, even if none has occurred there before	Site selection, especially in hills due to slope instability
	Take landslide mitigation measures for the site/ location at community/ regional level. Seek expert geological advice; through drain the top and sides of the landslide area; where appropriate use bioengineering for shallow landslides (less than 12 inches deep), use hard infrastructure where needed (e.g. check dams), vegetation, slope protection, geo textiles, micro piping, and other means	Locality and regional planning and infrastructure

As it can be seen from the table above, that there is not much that can be done at the school building level for risk reduction for floods and specially landslides in an economically feasible manner, except by proper site selection, and site protection.

4.3 For Environmental Sustainability

Various considerations for ES should be included in an integrated manner at different steps of the design and construction as shown in the table below. These should be compared with the relevant provisions of the relevant national codes by the architects and engineers for compliance.

Table 4-2 Various Considerations for Environmental Sustainability

Primary Aspect of ES	Considerations to Cover the Primary Aspect	Design and Construction Process Step
Soil and Environment Conservation	Avoid building on sites that are part of protected environmental zones, are ecologically sensitive (e.g. in ecological corridors or important wildlife areas), are covered by trees and vegetation that holds the soil together, or are cultural/religious sites	Site selection
	Minimize damage to land vegetation and soil around the construction site; try to leave trees for shade and soil stabilisation	Construction practices
	Design the building to follow the existing land profile to avoid excessive cut and fill, and to avoid being an eyesore in the landscape	Architectural planning
	Avoid blocking or diverting any exiting natural water ways or building on ponds or water bodies	Site selection and architectural planning
	Include planting of grass, vegetation and trees, if possible, within or around the buildings; consider planting hedges rather than building high walls, which could be dangerous in an earthquake; use trees for shade.	Architectural planning
	Prevent soil erosion by proper designing of storm water drainage and tree plantation	
Water Conservation, Harvesting and Recycling	Provide minimal water usage outlets, with just enough flow capacities, and water efficient fixtures wherever possible	Plumbing design
	Include rain water harvesting in design of roof	Architectural design
	Provide rain water collection and recycle system, either for each building or a group of buildings	Architectural planning and plumbing design
	Incorporate waste-water recycling wherever possible, each building or a group of	Architectural planning and plumbing design

Primary Aspect of ES	Considerations to Cover the Primary Aspect	Design and Construction Process Step
	buildings	
	If the school has piped water from a local source, look for opportunities to help protect the recharge area above the source restoring or maintaining forest there if possible.	
Energy Conservation, lower GHG, and Alternate Sources	Use optimum orientation of the building, location and size of doors and windows, provision of window shades, optimum ventilation, natural cooling or heating depending on the local climate, to optimize the use of natural daylight.	Architectural design
	Use energy efficient electrical system and light fixtures	Electrical design
	Provide proper insulation to the roof and walls to minimize heat gain (or loss for cooler areas). Simple solar passive heating as well as cooling system can be used.	Architectural design
	Of the available materials, select materials with higher insulation value to minimize heat gain or loss	Material selection, architectural design
	Consider incorporation waste to energy solutions for a group of buildings or a community, including installing biogas attached to toilets to make use of the sewage to reduce firewood or bottled gas consumption for cooking. Slurry from the digester can be used as compost in school gardens.	Architectural planning, plumbing and waste disposal, electrical design
	Choose local materials for construction as far as possible to reduce transportation efforts to reduce energy consumption and use construction materials with low embodied energy	Architectural design and structural design
	In those sites, where there is no electricity supply, solar PV cells can be used for lighting, running computers and Wi-Fi.	
Material Conservation and Re-use	Use minimal material through efficient design	Architectural design, structural design
	Minimize material waste through modular design and use materials of standardized sizes, or design to match material sizes.	Architectural and structural design and material selection

Primary Aspect of ES	**Considerations to Cover the Primary Aspect**	**Design and Construction Process Step**
	Incorporate reused and recycled materials into deign, wherever possible	Architectural and structural design and material selection
	Use proper construction practices, to reduce material waste and encourage proper waste recycle and disposal	Construction practices
	Provide small room for storage and sorting of re-usable materials.	
	Obtain materials from sustainable sources. When sourcing timber, follow Nepali forest laws and regulations, including community forestry rules. Procure sand, gravel and boulders from legal areas that do not cause increased risk of hazards such as landslides, floods, downstream sedimentation, and degradation of wetlands; or damage to infrastructure.	Architectural design, material selection and sourcing
Land Use Planning / Hazard Mapping	Refer land use map to identify safe areas for school construction	Urban and rural planning. Risk Sensitive Land Use Plan
Waste disposal	Dispose of unwanted relief materials (e.g. old tarpaulins), and construction waste including any hazardous materials, in designated areas away from streams, wetlands, and development; consult with local authorities on safe and environmentally responsible disposal areas.	
	Make provision for safe disposal of school waste, if the local authority does not already have adequate provisions.	

Chapter 5 Materials and Construction Considerations

5.1 Construction Material

The focus of location, design, construction and maintenance could be on using local building materials and the skills of community artisans. The locally available construction materials should be used according to national building code. The figure below shows good construction material used in present context.

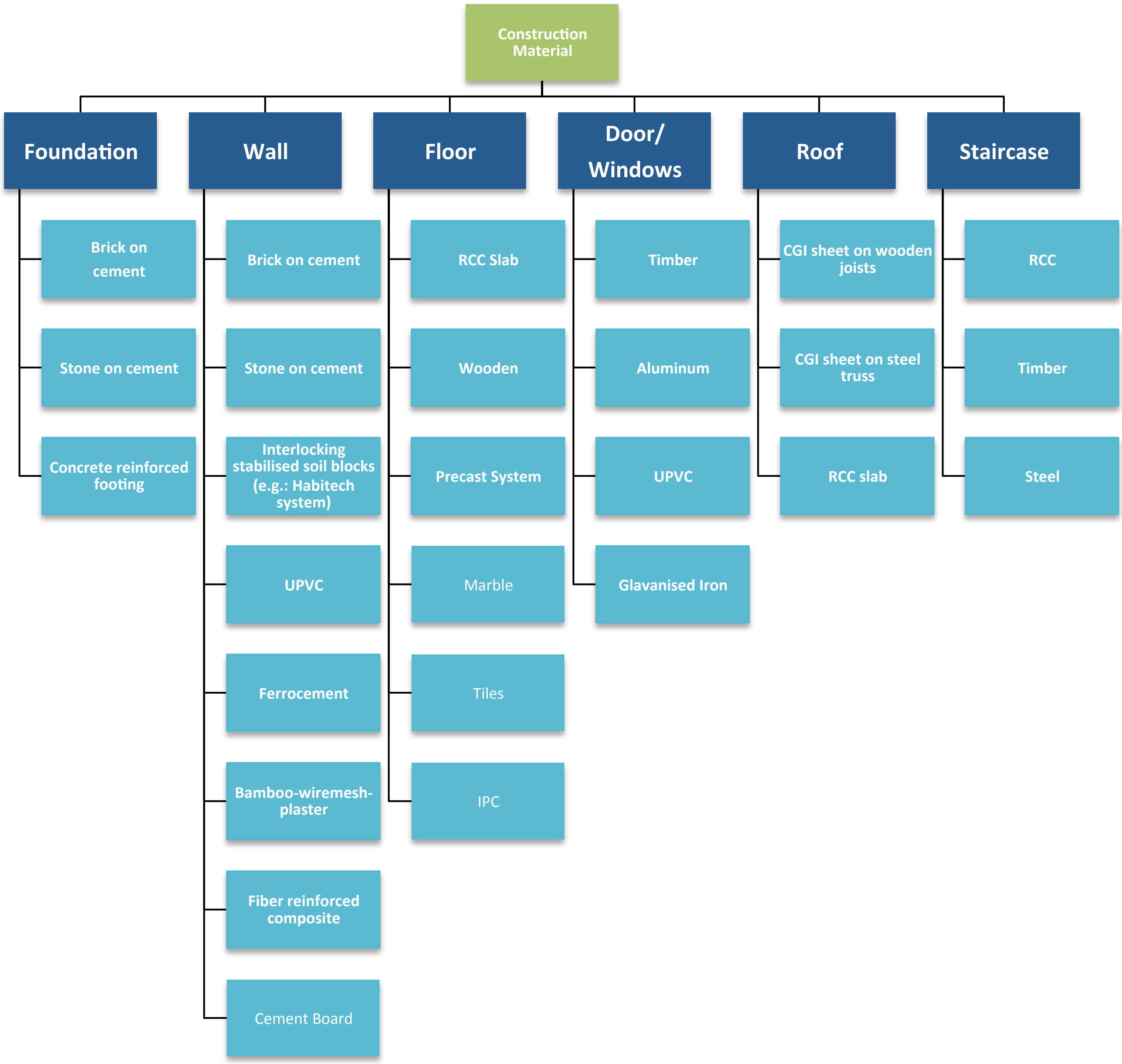


Figure 5-1Recommended Construction Materials

Chapter 6 Structural Design Considerations

6.1 Overview

It is extremely important to carryout proper structural design of the type design for various hazards, as well as for cost effectiveness. A system design approach should be used, as each type design will be replicated many times, and any safety, performance and cost effectiveness consideration will have wide ranging impact.

In general, a Performance Based Design (PBD) is recommended for the design of the school buildings. This approach, may not be feasible for individual design of specific schools, but should be used for superstructure of Type Design due to their repeated use. The foundation design may have to be specialized for specific sites.

Due to significance, as well complexities of the structural design considerations, a separate document is prepared for this purpose [4]. This document is expected be approved for distribution in March, and will also address the multi-hazard aspects for disaster resilience, and compliance to relevant building codes

[4] Interim Structural Design Criteria for Type Design of School Buildings, February 2016

Chapter 7 Site Infrastructure Design Considerations

7.1 Site Infrastructure Guidelines

7.1.1 School Size and Location

1. The size and location of the school should influence learning and should include green spaces that can be used for natural science lessons, student club activities, etc.
2. The school should be the integral learning and teaching space with proper playing grounds.
3. The size of school should be based on physical and curricular needs.

7.1.2 Assessment of topographical risk

4. Site selection for school should consider Land conditions (such as bearing capacity, landslide risk, slope of terrain), seismic zones, flood risks and the potential impact of local winds on school structures (allowing for more extreme weather events such as more intense rain and increased drought periods in the future due to climate change)

7.1.3 Hygiene, Sanitation & Water

5. Sanitation and water facilities should be simple and easy to use to encourage hygienic behavior and reduce the spread of diseases at school; there should be special focus on adequate toilets for girls and women teachers.
6. Natural lighting and ventilation of all the spaces should be well practiced for healthy school environment.
7. Test water against arsenic content (in case of underground water supply).

7.1.4 External Circulation and the School Entrance

8. The entrance to the site should be prominent and easy to find.
9. Provision should be made for access for all from the parking area. This access should be integral part of design which should also include people with special need
10. The school building should be located near to the main site entrance and clearly visible from that entrance.

7.1.5 Early Childcare facilities

11. Early childcare should be located within or near the school to facilitate the older children who are attending the school to leave their younger siblings at the center.

7.1.6 Emergency Situation

12. The school building should go beyond education acting as shelters or gathering places during emergencies such as hurricane, earthquake and flood.
13. Where relevant, the school should be linked to any early warning systems.
14. Consideration for regional schools or those particularly isolated should be given to providing additional facilities with dual purpose to a) help in the immediate response to disasters (e.g.: first aid, basic search and rescue equip., shovels,

ropes, firefighting equipment, etc.) and b) assist if the school was to be used as a post-disaster collection / refuge centre (such as additional toilets beyond what student numbers would dictate, blankets, emergency food and water etc.). The department would need to consider broader implications of this idea in terms of budgeting for upkeep and maintenance and ensuring community members are trained to use the equipment.

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3. School Furniture Handbook, Volume One & Two, 1979, **UNESCO**.

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5. School Facilitates Design Handbook, March 30, 2007, **Bureau of Indian Affairs, Office of Facilities Management and Construction**

6. School Facilities Space Templates, Bureau of Indian Affairs, Office of Facilities Management and Construction

7. Nepal National Building Codes(NBC 206: 2003), Architectural Design Requirements

8. Nepal National Building Codes(NBC 114: 1994), Construction Safety

9. Ernst and Peter Neufert, Architects Data, **School of Architect, Oxford Brookes University**

10. Time Saver Standards-Building Types, **Joseph De Chiara & John Callender**

11. **UNICEF (2002),** Child Friendly Schools Manual, UNICEF

12. Nepal Education Rules, 2059 (2002)

Appendices

Appendix A. Histograms

Histograms of various student numbers for different school types, grades etc. are generated to arrive at the appropriate needs and classification. These histograms are based on the EMIS database for the 14 districts. A separate analysis was carried out for comparing the histograms of the damaged schools only, vs. all schools nationwide, and it was found that the trends are almost identical between the two datasets.

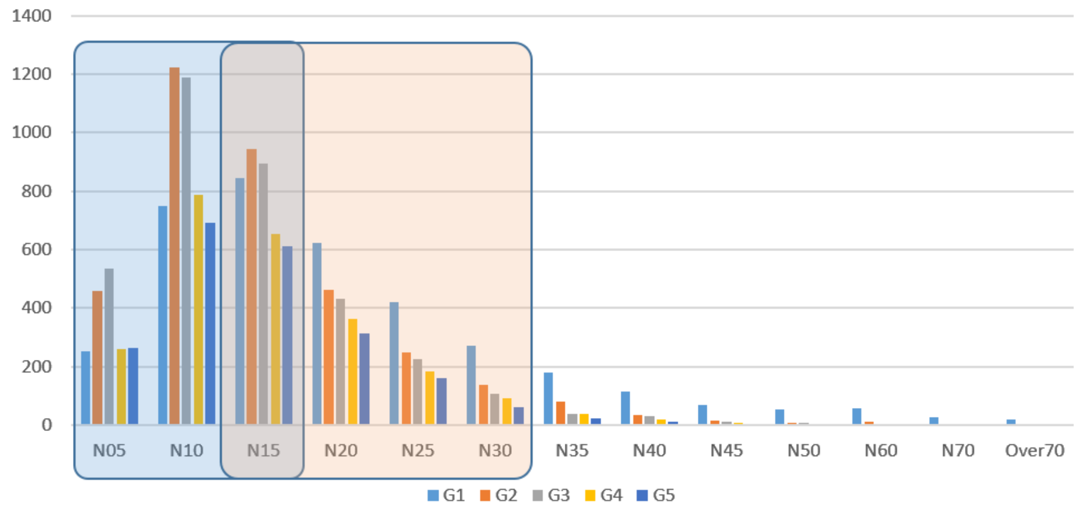


Figure A-1 PS Students Per Grade and Number of Schools

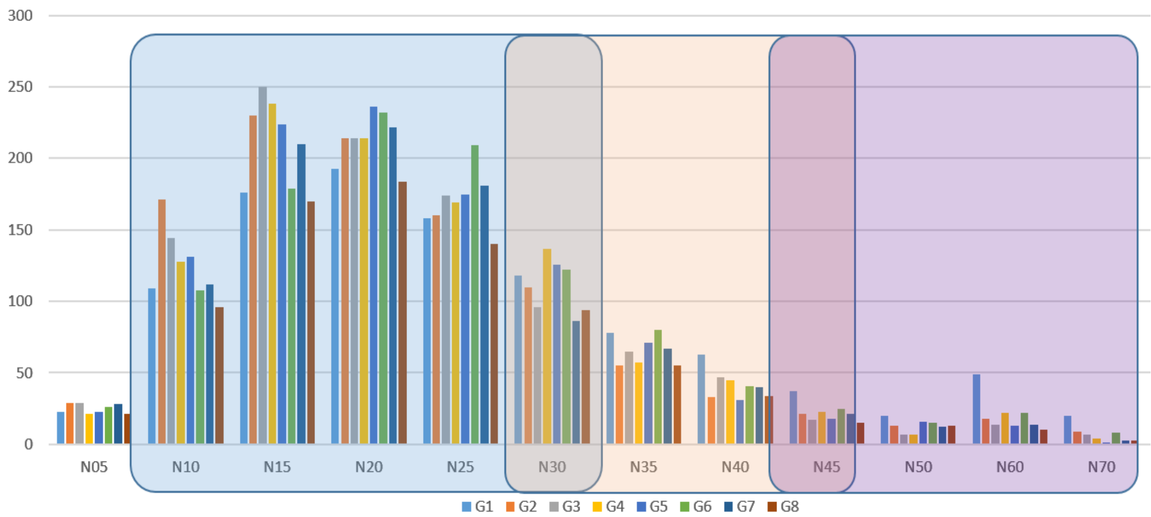


Figure A-2 LSS-Students Per Grade and Number of Schools

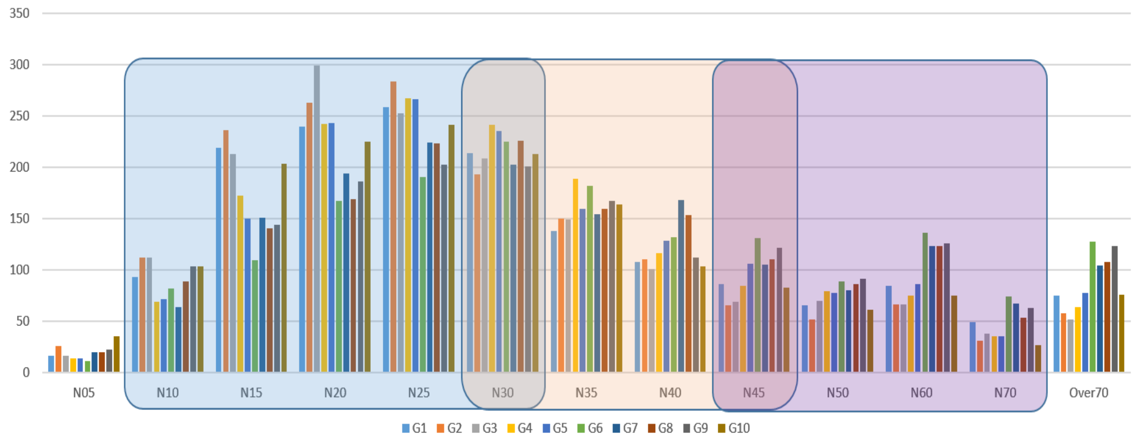


Figure A-3 SS-Students Per Grade and Number of Schools

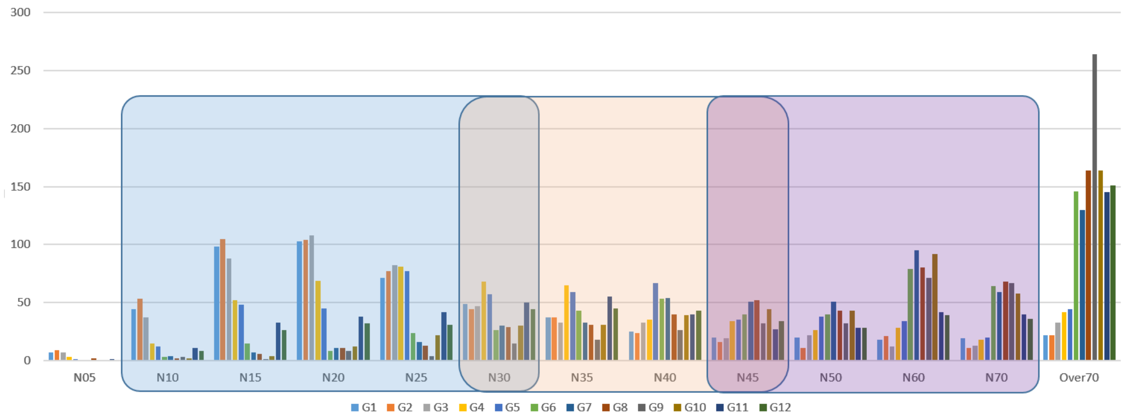


Figure A-4 HSS-Students Per Grade and Number of Schools

Appendix B. Construction Technology

According to geographical context of Nepal, 3 typical school buildings can be practiced which are appropriately designed for Mountain, Hill & Terai regions according to the environmental context and based on available local materials and local construction practices. The classroom sizes are based on Building Code and Standard. Use of available local materials is being practiced as much as possible so as to reduce overall construction cost of school buildings.

Tables B-1 to B-4 list some of the possible materials that may be considered for various applications. This list is neither exhaustive, nor a strict recommendation. Several new materials and technologies are being proposed in the market after the earthquake, and these need to be considered and evaluated careful for particular application to schools in specific cases.

Hill and Mountain Belt

Rocky hills and mountains prevail over using stone structures in these regions. Mud or clay and wood are locally available in some hilly regions but they are very difficult to find in mountainous regions or highlands. The hilly building structures are mostly constructed with mud mortar. Nowadays, the cement-sand mortar is being practiced even with the high cost of transportation (due to geographical difficulties). If load-bearing structures are correctly practiced with the appropriate use of structurally efficient technology and with the use of locally available materials, they can't be denied as the disaster resilient structure for the school buildings.

Table B-1 Conventional Construction Practice in Mountain Region

Building Components	Materials in Practice	Construction Detail
Foundation	Stone-cement mortar, Stone-mud mortar (for single storey and always use binding materials for strengthening)	Strip Footing of stone for Load bearing structure
Wall	Stone-cement mortar, Mud Plaster, Cement Pointing, Wood Partition, Bamboo Partition, Stone-mud mortar (length up to 4.5 – 5 m)	Stone Masonry Wall of 350mm
		Reinforcement bars in both sides of each opening (use of wood or bamboo in upper regions)
		Wooden Sill Band
		Wooden Lintel band
		Buttress Wall Construction (usually 2.8m c/c apart)
Floors	Wood, Cement-Sand RCC, Wooden planks	PCC Floors in Ground Floor (dry brick soling) (Wooden floors in highland)
		RCC floor in upper floors (Wooden floors in highland)
Flooring	Mud Flooring, Stone Flooring, Cement flooring with stone soling in GF, Wooden Planks	Cement Sand Plaster
		Wooden Planks above wooden Joists
		Mud Plaster IPS Flooring

Roof	CGI Sheet, Mud with wood planking, Slate, Thatch	CGI Sheets
		Wooden Rafter and Purlins
		Wooden Planks of false ceiling
		Wooden Eaves board
Doors & windows	Locally available wood, CGI/plain sheet with wooden frame	75 mm x 100 mm Frames
		Single wooden panel shutter in doors
		Double wooden panel shutter in windows
		Louvered ventilation above each doors and windows
Staircase	RCC, Wooden planks, Steel or wooden railings & Baluster	RCC/Wooden Staircase
		50mmØ and 12mmØ MS pipe (or wooden) railing
		25mmØ MS pipe (or wooden) Baluster

Table B-2 Conventional Construction Practice in Hilly Region

Building Components	**Materials in Practice**	**Construction Details**
Foundation	Stone-cement mortar	Strip Footing of stone for Load bearing structure
Wall	Stone-cement mortar, Mud Plaster, Cement Pointing, Brick – cement mortar, cement plaster	Stone Masonry Wall of 350mm
		Reinforcement bars in both sides of each opening
		75mm RCC Sill Band
		No Lintel Band as Beam acts as Lintel band
		Buttress Wall Construction (usually 2.8m c/c apart)
Floor	Wood, Cement-sand, RCC	PCC Floors in Ground Floor (dry brick soling)
		RCC floor in upper floors
Flooring	Stone Flooring, Cement flooring with Stone soling in GF, Wooden Planks	Cement Sand Plaster
		Wooden Planks above wooden Joists
		Mud Plaster IPS Flooring
Roof	CGI Sheet, RCC Steel Pipes, Plywood, Wooden Board	CGI Sheets
		Tubular Steel Truss
		Plywood False Ceiling
		Wooden Eaves board
Doors & windows	Locally available wood, Plywood/wooden boards, CGI/plain sheet with wooden frame	75 mm x 100 mm Frames
		Single wooden panel shutter in doors
		Double wooden panel shutter in windows
		Louvered ventilation above each doors and windows
Staircase	RCC, Steel Pipes, wood	RCC Staircase
		50mmØ and 12mmØ MS pipe for railing
		25mmØ MS pipe for Baluster

Terai Belt

Stone is rarely available in this region. The locally available construction materials are clay/mud, bamboo, wood, clay bricks, straw for roofs, etc. So, in this area, mostly the RCC structures with brick walls are constructed with wooden doors and windows.

Table B-3 Conventional Construction Practice in Terai Region for Frame Structure

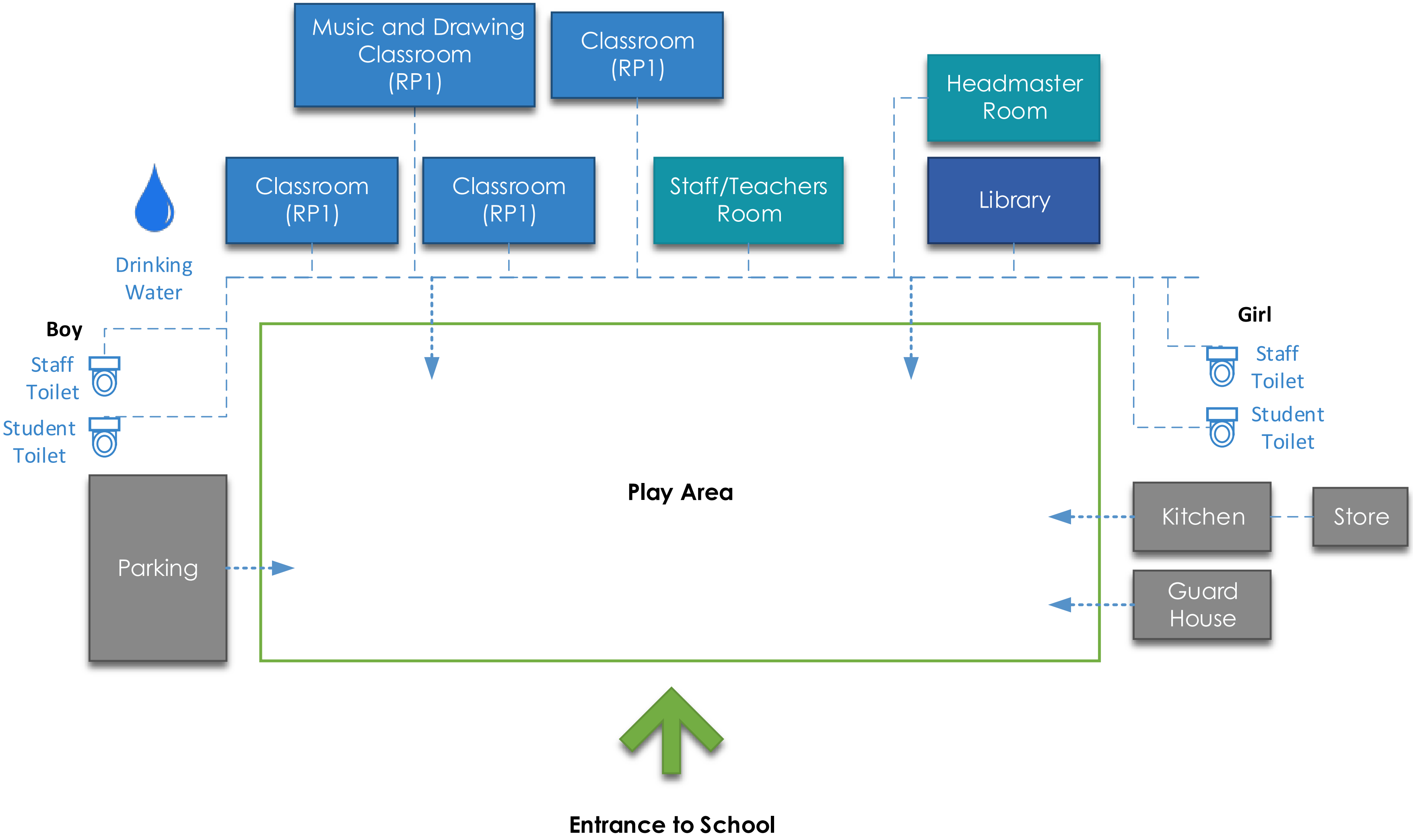
Building Components	Materials in Practice	Construction Details
Foundation	RCC, brick, stones	Isolated Concrete footing
Wall	Brick-C/S mortar, RCC Bands, Brick mud – mortar (length up to 4.5 – 5 m)	Brick Masonry in cement sand mortar
		RCC Sill & Lintel Band
Floor	Wood, Brick, Cement-sand, RCC	PCC Floors in Ground Floor (dry brick soling)
		RCC floors with cement sand plaster
Flooring	Cement flooring with Brick soling in GF	Cement Sand Plaster
Roof	RCC	RCC Roof
Doors & windows	Wood, Glass	75 mm x 100 mm Frames
		Single wooden panel shutter in doors
		Double glass panel shutter in windows
Staircase	RCC, Steel pipes	RCC Staircase
		50mmØ and 12mmØ MS pipe for railing
		25mmØ MS pipe for Baluster

Table B-4 Conventional Construction in Terai Region for Loadbearing Structure

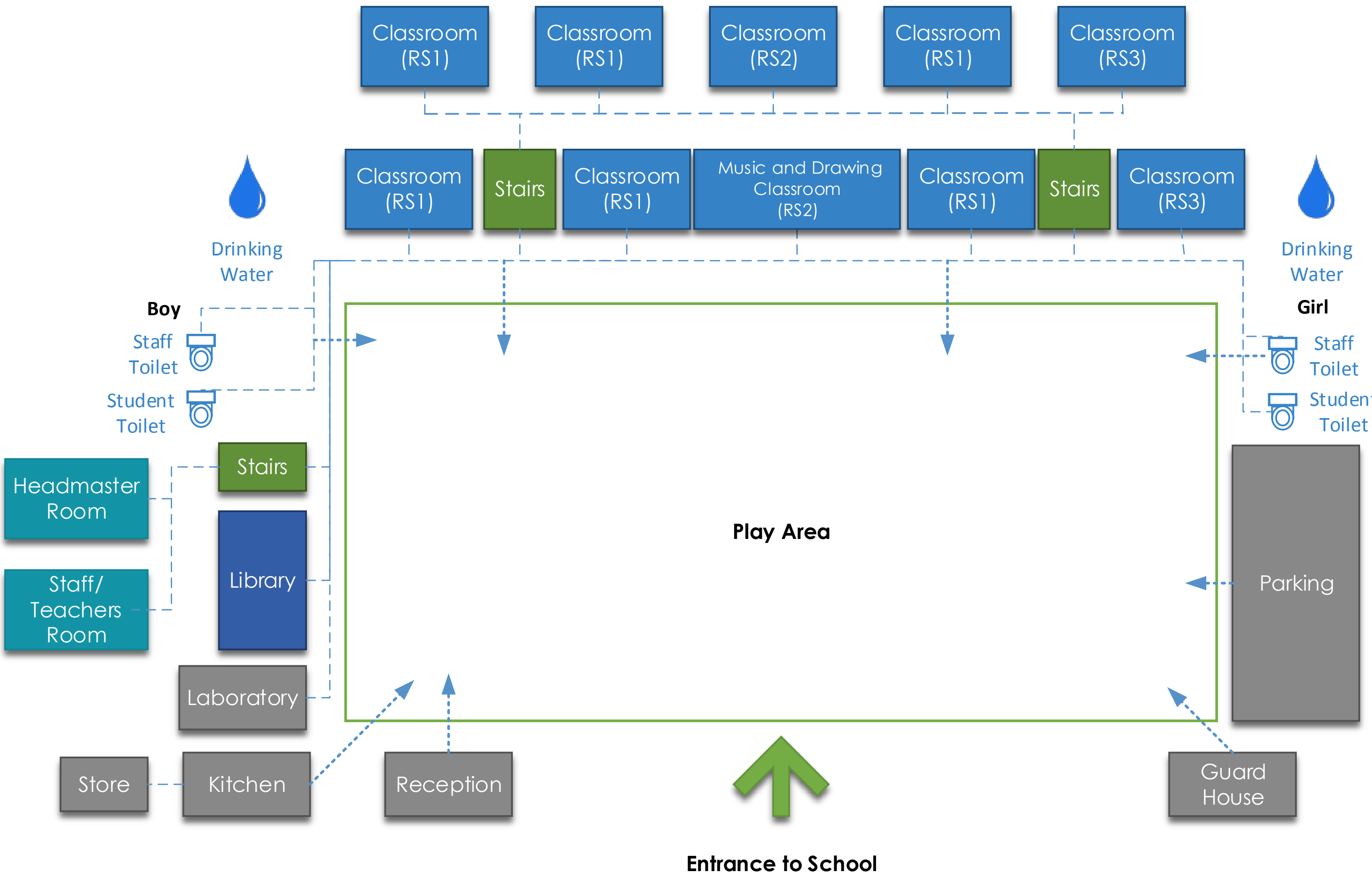
Building Components	Materials in Practice	Construction Details
Foundation	Brick-C/S Mortar	Strip Footing of Brick for Load bearing structure
Wall	Brick-C/S mortar, RCC Bands	Brick Masonry in cement sand or mud mortar
		RCC Sill & Lintel Band
		Buttress Wall Construction (usually 2.8m c/c apart)
Floor	Wood, Brick, Cement-sand, RCC	PCC Floors in Ground Floor (dry brick soling)
		RCC floor in upper floors
Flooring	Cement flooring with Brick soling in GF Marble Flooring	Cement Sand Plaster
		Mud Plaster IPS
Roof	CGI Sheet, Steel Pipes, Plywood, Wooden Board, tiles, CGI, Thatch, RCC	CGI Sheets
		Tubular Steel Truss
		Plywood False Ceiling
		Wooden Eaves board
		RCC
Doors & windows	Wood, Glass, Galvanised Iron	75 mm x 100 mm Frames
		Single wooden panel shutter in doors
		Double glass panel shutter in windows
		Galvanised Iron section and sheets
Staircase	RCC, Steel pipes	RCC Staircase
		50mmØ and 12mmØ MS pipe for railing
		25mmØ MS pipe for Baluster

Appendix C. Space Diagrams

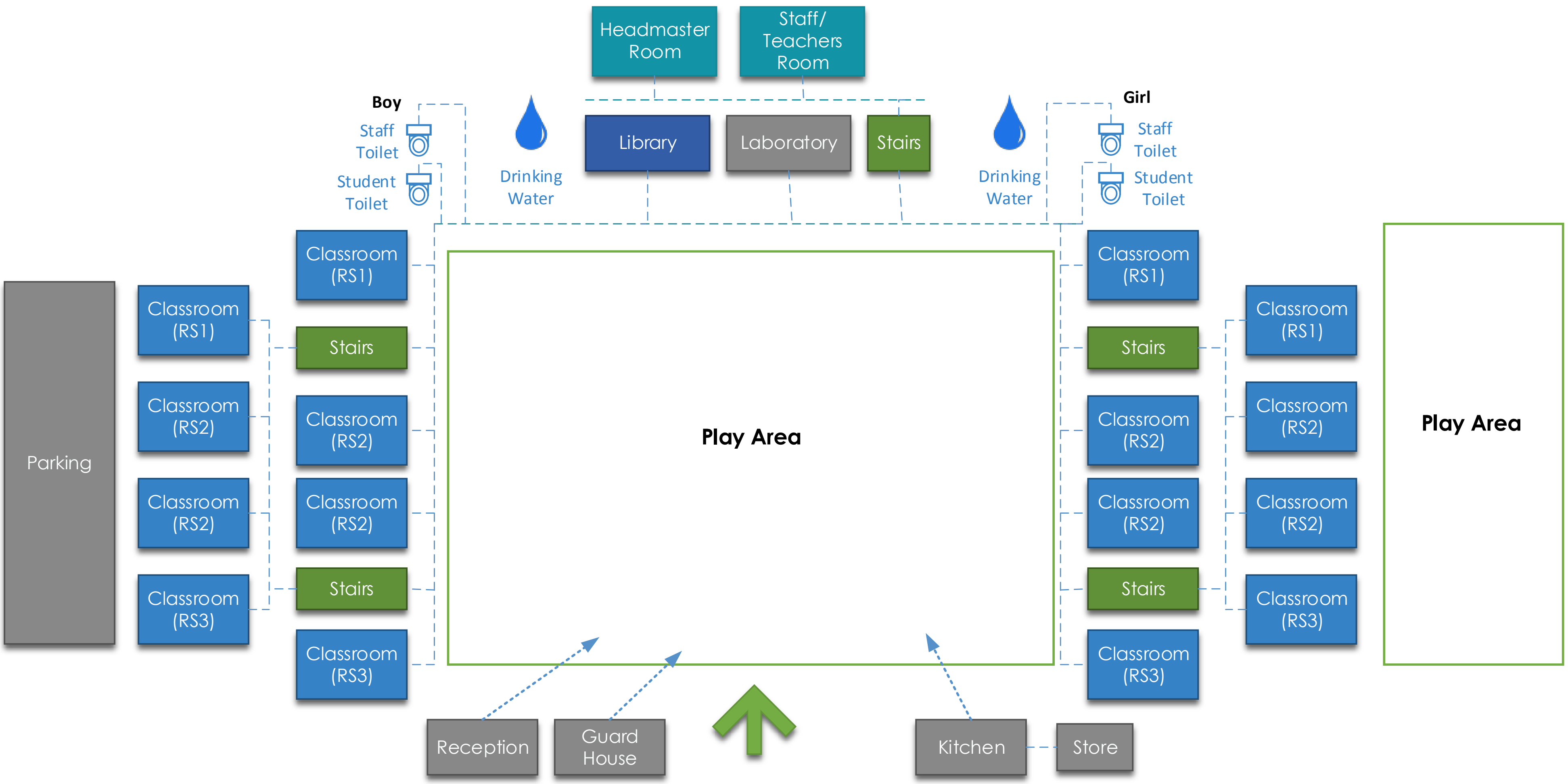
Primary School (TD-PS1)
School Size (Very Small-Medium)
Student Number up to 100



Lower Secondary and Secondary School (TD-LS1, TD-LS2, TD-SS1, TD-SS2 & TD-SS3)
School Size (Small-Large)
Student Number up to 480



Higher Secondary School (TD-HS1 & TD-HS2)
School Size (Medium-Very Large)
Student Number up to 650



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