CAMPUS ON THE SABARMATI

IIT GANDHINAGAR

PLANNING THE SUSTAINABLE CAMPUS

PROCESS AND FEATURES OF MASTERPLAN

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Note:

Most of the text, drawings and graphic material in this publication were prepared by Green Campus Development Consortium (Space Design Consultants and Upalghosh Associates) and presented to IIT Gandhinagar in 2012 as a report entitled Planning an Environment Friendly Campus. It is hoped that this publication will be of interest to design professionals as well as others interested in campus planning and development, and that it will also serve as a useful educational tool for students and young professionals.

All cost figures are given in Indian rupees, typically in crores.
One crore=100 Lakhs; or 10,000,000 rupees.

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FOREWORD

Once created, universities may last not just decades, but centuries. Hence, it is a rare privilege for anyone to participate in the process of creating a new university. Establishment of the Indian Institute of Technology Gandhinagar (IITGN) has enabled all of us associated with the Institute to innovate in creating curricula, organizing governance, and nurturing a unique culture and ethos of the Institute. The philosophy of education has been to push traditional boundaries with an emphasis on multi-disciplinary approaches and crosscutting thematic areas.

Just as the Institute endeavours to think out of the box for its academic programmes and governance, it has also been doing so for development of its 399-acre campus on the banks of the Sabarmati River. It is our firm belief that the physical environment makes a huge contribution to shape the processes of learning and knowledge creation. The campus has been conceptualized keeping in mind the long-term objectives as well as the present needs and immediate future. The guiding principles of the campus development have been

- An ambience that attracts visitors and conveys to them that they are on a university campus unlike any they have visited before.
- Functional convenience for the academic community for mutual interaction, learning and research.
- Low energy and resource consumption, as well as minimal upkeep and low maintenance costs.

The engagement of a large number of professionals and academics in brainstorming and in executing the design and construction has enabled us to introduce numerous innovations in the development of the campus. This publication is one in a series that explains the complex decision making, design, and construction process for the new campus. The publications in this series have been made possible because of several visits of Marjorie Greene to IITGN as a Scholar-in-Residence. She worked to systematically compile the various materials presented here, collaborating with IITGN colleagues as well as our architects and consultants.

ABOUT THIS PUBLICATION: This publication showcases the master planning process for the new campus. The campus development work was split into master planning and architectural design. The Masterplan development was completed by a consortium of architects selected through a competitive process. Another selection process was conducted for the comprehensive architectural design of the student hostels, the faculty and staff housing, and the academic buildings. A landscape architect and member of the master planning team oversaw the landscape design for the overall elements and spaces of the new campus. This landscape architect also peer-reviewed the landscaping developed as part of the hostels, faculty and staff housing, and academic buildings. Active participation from the IITGN community—students, staff, faculty, owner's architect and other well wishers enabled a very collaborative process that provided the overall vision and structure for campus development. This publication, written for the most part before campus construction began, describes the process and approach used by this master planning team.

Sudhir K Jain
Director and Professor
Indian Institute of Technology Gandhinagar

EXECUTIVE SUMMARY

IIT Gandhinagar was created as one of the eight new IITs in 2008 with a sanctioned strength of 2400 students. Prof Sudhir K Jain was appointed director for an initial period of 5 years in 2009. The temporary campus was set up at VGEC Chandkheda, Ahmedabad, in 2008, and some new buildings were added to that existing campus. In 2012, 399 acres of land for the new campus was handed over by the Government of Gujarat, Gandhinagar, on the western bank of the Sabarmati River.

A committee of experts brainstormed to discuss the process to build the campus. As a result, the campus design and development work was split into two parts- Masterplan and architecture. IITGN invited applications for pre-qualification of master planning firms in 2010. Six firms were selected to participate in an international competitive process that called for the Masterplan to create:

- An ambience that sets the campus apart from others
- Functional convenience that provides and promotes interaction among students and faculty
- A campus that uses resources efficiently and leads to a GRIHA rating for buildings and the whole development.

Green Campus Development Consortium (GCDC) with Space Design Consultants and Upalghosh Associates as partners was selected as the master planner in November 2011 and they were appointed to do the work in February 2012.

The first set of buildings are to house about 1200 students and associated staff. The first phase of the project has been designed for 2400 students and the overall plan included the second phase that would bring the student strength to 4800 and provide scope for further expansion to 6000 students.

The 399 acre site has a difficult terrain and only about 55% of the site is available for development in different pockets. The southern parcel has a large contiguous area suitable for the main campus. The central and northern parcels are smaller and undulating, better suited to small independent uses.

To increase the usable area in the southern parcel, small depressions are to be filled up with construction waste. The northern parcel is to be used only in part leaving a substantial portion as habitat for ‘nilgai antelope’ and other existing fauna. Many sections of the ravines lie below the highest flood level of the Sabarmati River, and the Masterplan calls for the river bank to be protected from erosion during floods.

The Masterplan envisioned a campus on the Sabarmati River, determined in large measure by the river bank location and the extensive ravines. It was planned as a green campus with an emphasis on pedestrian movement, largely free of vehicular traffic. The layout was designed to maximise views along and across the river and to retain two existing natural depressions. The visitors’ entrance to the campus was planned using a major ravine as a scenic drive. There are two other entrances to the campus for the staff and students.

A participatory design process was followed by IITGN, wherein faculty, staff and student representatives were part of the committee that discussed the Masterplan with GCDC. Several different layout possibilities, both dispersed and compact, were tried before the present compact plan was selected. This plan places the main campus for ultimately more than 4800 students in the southern section of the site.

The Masterplan defined land parcels for various uses in terms of size, shape and development potential. The phasing of development was also defined. The built form of the campus is mainly ‘low-rise’ with elevator-free buildings. Only a few high-rise apartments were proposed to give better definition to open spaces and to add interest to the skyline. The predominant building form is the courtyard type. Gateways, courts, colonnades, water features and a shaded academic spine are the major architectural components of the campus.

The urban design controls in the Masterplan control the movement systems, infrastructure systems, land use parcels and the buildable areas in those. The shape, location and size of the Arrival Court, the Academic Spine, the Arcade, the Central Vista, the Greens, and the major Hostel Court were also controlled. The urban design of the campus was not intended to control the architectural expression, style, material or colour, although suggestions were made to not use certain materials on campus. These included aluminium composite panels and high pressure laminates of acrylic.

It was proposed to treat sewage at the campus through a two-or three-stage process consisting of an anaerobic bio-reactor and constructed wetlands (root zone treatment system) and then to use the treated water on the site with zero discharge. After ultra filtration, the treated water is being used for flushing toilets and irrigation. Rainwater collected from roofs is stored and used after filtration and disinfection. Rainwater collected from open spaces on-site is being charged into the ground. The shortfall of water is made up by a dedicated pipeline from Narmada Canal.

Solid waste is sorted, collected, treated to a large extent, stored and disposed of on-site. Biodegradable waste is being treated through biological processes.

The power supply is available at 11 KV initially and will be at 33 KV in later stages. Power is distributed at 11 KV and unitized sub-stations are provided at the building cluster level. The available power supply is stable and only the academic areas have some buildings with a standby power supply.

A fiber optic cable supplies all communication requirements in the campus.

A fire alarm system serves the hostels and academic buildings.

Buildings are being built to Green Building Rating Systems India (GRIHA) and Energy Conservation Building Code (ECBC) standards. The Masterplan attempted to make this an exemplary project for sustainable development. The IITGN campus Masterplan subsequently was awarded a 5-star GRIHA rating in the large development category in 2016 and was first in the country to win such a rating.

The Masterplan allows IITGN to plan the infrastructure and to use different architects at different times or even at the same time to design buildings while adhering to the Masterplan’s guidance on the overall character of the campus. Initially three different architectural firms were retained by IITGN to design the academic and residential buildings.

ACKNOWLEDGEMENTS

IITGN would like to acknowledge the exemplary leadership and visionary spirit of the Green Campus Development Consortium, in particular the project leader Dr Vinod Gupta, the urban designer Ar. Ujan Ghosh, and the landscape designer the late Prof Mohammad Shaheer. Their imaginative vision for what the IITGN campus could be, and their ability to translate this vision into the master planning framework has guided all aspects of campus development.

IITGN would like to acknowledge the contributions of all stakeholders in the construction of the IITGN permanent campus; architects and structural designers, Central Public Works Department (CPWD) engineers, contractors and the construction workers.

Appreciation must be directed to all the members of the IITGN community (students, staff and faculty) who participated so enthusiastically in the planning process. Specific mention must be made to acknowledge the contributions of Prof. Ashwini Kumar, Visiting Professor, Civil Engineering; Prof. Amit Prashant, Dean, Academic Affairs; Mr. Shobhit Tayal, Director, Design & Planning Counsel Pvt. Ltd.; Mr. Nagaraja Billur, Mr. L P Srivastava, Advisor, Works Department; Mr. Anil Kothari, Superintending Engineer and Mr. G C Chaudhary, Superintending Engineer from IITGN.

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The project would not have been possible without the effort and dedication of all these people.

This project would also not have been possible without the financial support provided by the Government of India.

Prof Mohammad Shaheer

Soon after the conclusion of the Masterplan design of the IITGN campus, on November 28, 2015, Professor Mohammad Shaheer passed away peacefully in his sleep. What follows is IITGN Director Professor Sudhir K Jain's eulogy, written as a Facebook post the day after Prof Shaheer's death.

Professor Mohammad Shaheer is no more...he went 'home' peacefully in his sleep yesterday morning. He was the country's top landscape architect, and made huge contributions to the design of IIT Gandhinagar's Palaj campus.

I heard his name for the first time when he designed "Park-67" at IIT Kanpur, where I used to take walks in the evenings. I first met him when he (together with Dr Vinod Gupta) presented before the IITGN evaluation committee a concept Masterplan for the Palaj campus... we immediately recognized that (a) it was a beautiful concept, unlike any that we had seen over two days of presentations by others (it was the last presentation), and (b) this concept had a lot of inputs from Prof Shaheer (even though he was not a partner of GCDC; the firm he was representing). We awarded the work to GCDC with a condition that Prof Shaheer MUST remain part of the design team throughout. Over the next several months, we greatly enjoyed working with him on the Masterplan, and realized that in him we not only had a very creative architect but also a very wise person.

When time came for the design of the buildings and facilities, we decided to retain Prof Shaheer and his firm for the landscaping work. He had some reservations when I called him on the phone, and I assured him... "Professor Shaheer, we are going to build the best academic campus in the country (and possibly the world) and we need you...we will not let a single tree be planted if you do not approve of it.... please let us know what conditions will enable us to avail of your services and we will try to meet those conditions".

He not only undertook landscape work for the campus, but also carried out the peer review of all landscaping work done in hostel, housing, and academic parcels. He was a stern and tough teacher, as I saw him guide the young landscape architects of other firms .... but very understanding and very humane. His presence in our large team of architects and professionals has been extremely reassuring to us in general and to me personally...we knew that he would point out if we were making mistakes somewhere.

Prof Shaheer....your creativity and wisdom have left a huge imprint on the IITGN campus...please be assured that we will not let you down... that you will smile from your 'home above' at the great campus that has started to emerge....your hard work in design of a beautiful boundary wall (we hope to start this soon) and on the 2000 capacity amphitheater will be masterpieces ...that generations of students, faculty and staff will be grateful to you.

It is a huge loss to us...to IITGN...to me...I will miss you, Professor Shaheer...Rest in peace.....

Facebook post by Prof Sudhir K Jain, Director on November 29, 2015.

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1 Development Programme

Campus planning is about the development of an institution for learning, a place for students and staff to live, work and learn. Learning is a continuous process not limited to the classroom and master planning is about creating the conditions under which learning can take place. Campus design revolves around the site and its geographical and climatic context, access to the site, development potential of the site (zoning and bylaws), organisation of components on campus, the conceptual design framework, phasing of development, and vehicular movement and parking. The client's own requirements can include other functional and aesthetic requirements. With climate change in mind, many owners now ask for resource conservation and green certification. While the norms for green buildings are well established now, there is no agreement as yet on what constitutes a sustainable campus. At the outset of the design process, it was therefore decided to define clearly the issues for developing a sustainable campus for IIT Gandhinagar. These included

- Built space requirements
- Efficient use of land and built space
- High density campus
- Zero water import
- Zero energy import
- Zero waste export
- Mobility without cars
- Preservation of bio-diversity
- Social equity
- Cultivation of food on-site
- Harvesting energy on-site

These goals set the bar higher than what GRIHA Large Developments or Leadership in Energy and Environmental Design-Neighborhood Development (LEED-ND) certification requires. There are other well-known functional and aesthetic issues of urban design and landscape design that all plans must address. To deal with these varied goals, the process of design required a careful assessment of the available resources on-site and their efficient use.

1.1. Built space requirements

The initial set of space requirements as determined by Green Campus Development Consortium (GCDC) and the committee of stakeholders is shown in Table 1.

	Phases	1	1A	2	
	Total Number of Students	**1200**	**2400**	**4800**	
		Areas (in sq m)			Total area
A	Administrative area	0	6293	0	6293
B	Academic area	25230	19129	44359	88718
C	Lecture Halls & Teaching Labs	8508	7845	16353	32706
D	Central Facilities	0	12775	11720	24495
E	Sports Facilities	0	7300	0	7300
F	Services	6100	0	4475	10575
G	Staff Residences	50600	38940	86075	175615
H	Guest House Complex	0	4050	4050	8100
I	Married Student Housing	0	7980	7980	15960
J	Student Hostels	42900	51600	56700	151200
	Total for Built space for phase	**133338**	**155911**	**231712**	**520961**
	Grand Total for Built space				**520961**

Table 1. Built space requirements as determined during development of Masterplan

The following sections describe general goals for a sustainable college campus, as articulated at the time of the selection process for the Masterplan. They were meant to provide context for the Masterplan, and in most cases provided guidance for specific goals that were then developed for IITGN. These IITGN goals are discussed further in this document as well as other documents in this series.

1.2. Efficient use of land and built space: *How much is enough?*

There are no standards as such in India for how much land and built space is needed for an institute like IIT Gandhinagar. While there are some norms for minimum requirements by the All India Council for Technical Education (AICTE) for typical engineering colleges, those are not applicable for the IITs considering the entirely different level of expectations from the IITs.

The requirements for land and built space per student will vary widely considering the following factors:

- Residential versus non-residential campus: A residential campus clearly requires more built up area and land area. Within a residential campus, the capacity may vary depending on (a) the ratio of students living on-campus versus off-campus, and (b) the ratio of faculty and staff living on-campus or off-campus. Similarly, the ratio of post-graduate students who may require married accommodation can vary. The IITs are expected to be fully residential institutions.
- Engineering versus other disciplines: Engineering programmes require a lot more laboratory space than liberal arts, social sciences, management, natural sciences, or information technology.
- Undergraduate versus postgraduate programmes: The space requirements are more per post-graduate student, as compared to an undergraduate student.
- Teaching versus research emphasis: Research programmes require significantly more space not just for the research laboratories, but also for office space (and residence) of the research personnel who are not students (for instance, post-doctoral students, research staff, technicians for the laboratories, etc.)
- Location of campus: A campus away from urban areas will require more space, since many amenities such as hospital, school, shopping, bank, etc. will need to be provided on the campus.
- Expected lifestyle: For instance, what is the level of outdoor sports facilities expected on campus?
- Nature of terrain and site conditions: These can significantly influence the capacity of a site to cater to a given size of student population.
- Local regulations: These may restrict (a) the building footprint on the land, (b) FAR (floor-area-ratio) on the site, and (c) the building height. These may influence the land requirements.

The IITs have evolved quite a bit in the last 60+ years, from primarily undergraduate-centric institutions to research institutions. Current expectations in the country are for the IITs to further scale up their research to make a larger impact on the economy and on the society. Considering the current profile of typical older IITs, it seems that about 20 to 25 students per acre is a good benchmark for the land requirement for the IITs. (Worldwide, land requirements at universities vary from 2 students per acre to several hundred students per acre).

A large part of the 399 acre site of IIT Gandhinagar consists of deep ravines that cannot be utilized for construction, leaving effectively about 220 acres of usable land. Hence, it appears that 5,000 to 6,000 students may be the maximum capacity that can be provided for on the land available at IIT Gandhinagar.

Considering the capital and operating costs involved, it is important that the built space required is decided after careful consideration of needs and not just based on available financial resources. Moreover, energy and water consumption will go up with an increased built-up area, even one serving the same population of students and faculty.

1.3. High density campus: *Does it need to be high-rise?*

One common perception that persists in spite of some evidence to the contrary is that a high-density campus needs high-rise buildings. With low-rise buildings the space between the buildings can be significantly less. In fact, a low-rise campus can be designed such that the space between the buildings functions at a more human scale, and in the process more effectively utilized.

1.4. Zero water import

The carrying capacity of a site can be defined in different ways and in a water-scarce area an important factor is the sustainable quantity of water available. All towns in the desert areas of Rajasthan, for example, depend upon rainwater, even though the annual rainfall is only a few hundred millimetres. As these towns demonstrate, a sustainable water source may be from the site itself or from distant areas. A project requires water first for construction of the buildings and later for use by the residents. Even if rainfall at the site is insufficient for the complete needs of the built project, with proper and timely action it is almost always sufficient for construction of the buildings. Zero import of water is an ideal which can be achieved if the needs of the residents are managed and matched with the availability of water.

1.5. Zero energy import

On large campuses, 'net zero energy' is also possible when the needs of the project are managed well. In most campuses, zero energy import is technically feasible and the main issues are of financial viability.

1.6. Zero waste export

Waste generation at the site starts with construction of buildings and infrastructure and continues all through the life of the project. It is possible to manage wastes such that construction wastes are minimized and used within the site, and organic wastes are composted and used as manure. However, as the campus is still getting established, there are large amounts of goods that are brought into the campus every day. A lot of waste materials are generated, particularly e-waste, that all need to be sent off campus. At this point in campus development zero waste export is not yet possible to achieve.

1.7. Mobility without cars on campus

One of the goals of IITGN is to be a car free campus. And yet, the residential campus requires transportation to connect it to the surrounding areas and to connect residential areas to the institutional areas within the campus. As the size of the campus grows, so does the need for internal transportation. The Masterplan specified that the actively used areas of the campus be kept small enough for walking and that the use of automobiles be limited to connections with the surrounding areas. Using appropriate planning measures, such as safe, shaded and rain-protected walkways, walking can be encouraged and automobile use discouraged. Unfortunately, most campuses are planned with automobiles in mind, and walkways are limited only to the margins of roads. If car use is limited on campus, an alternative system of transportation is required to take care of the needs of young children, seniors and the physically challenged.

1.8. Preservation of bio-diversity

Many green field sites have flora or fauna that need to be preserved. Sometimes these may not be obvious. There are also site features such as water courses and water bodies that need to be respected and preserved. The best value of land is not derived simply from how much can be built upon it but also by leaving space for activities that require open space.

1.9. Social equity

It is generally the privileged of Indian society who live and work in institutional campuses of higher learning. While there are small differences in the income levels of those employed by the institution, there are larger inequities that become obvious when one looks at people indirectly employed by the institution. A large campus can take many years to build and a large construction work force is engaged in carrying out the works. It is necessary that the needs of construction labour, outsourced staff and sub-contracted workers be taken care of at the campus. Large institutions impact the population of the surrounding areas even before they are established. In many cases land owned by villagers is acquired and handed over to the institution by the government. While many villagers will welcome the infusion of capital into their economy, it can also result in disruption of access routes, means of communication, grazing lands and even water supply. It is important that the institution concern itself with the welfare of the impacted population as well.

1.10. Cultivation of food on-site

Residential complexes produce solid and liquid wastes that need to be disposed of. With proper treatment many of these wastes can be converted to solid or liquid compost that can be used for cultivation of plants. Fresh vegetables grown with such compost are welcome on any dining table. Every campus has extra land available during the initial phases, land that can be used for growing food. Planning can ensure that when the campus is fully built, space is still available for growing food. Space-saving techniques such as hydroponics, aquaponics and aeroponics may also be used. The major advantage of growing food on campus is that the nutrients that agriculture requires are available free of cost in the solid and liquid waste from residential areas. Compost produced from wastes can be used to grow food organically.

1.11. Harvesting energy on-site

Keeping climate change in mind, it is necessary to harvest natural energy on a campus. While it is common for campuses to meet their commitment to use renewable energy by installing photovoltaic panels on buildings, most often they end up looking unsightly. PV panels may also contribute to the urban heat island effect. Other sources of energy such as wind or biomass may also be available but they require a little more planning.

These goals have been translated into some innovative sustainable management practices on the IITGN campus:

- Using building design to reduce heat gain (building orientation, materials, placement of windows, cooling shafts, etc)
- A biogas plant that utilizes green waste (kitchen and agricultural) to generate energy
- A sewage treatment plant that uses anaerobic reactors to digest sewage solids and a root zone treatment system that then treats this effluent so that it can be used for flushing of toilets and horticulture.
- Solar water heaters for all the residences
- Solar panels to generate power
- Rainwater harvesting and storage in jal mandaps
- Widespread recycling across campus
- An organic farm on-site
- A share-a-bike scheme where bikes are available for use at various stations throughout the campus

a) Academic building PV panels

b) Housing solar water heaters

Figure 1: Examples of sustainable building practices

Selection process for Masterplan consultants

2 Participatory Design Process

2.1. Participatory planning

As the new campus involved many innovative concepts, it was decided by the administration that all stakeholders (administration, faculty and students) be part of the consultative process that defined the policies for the new campus. The first step towards this was the formation of committees to oversee the development of the campus. The master planner was selected through a design competitive process open to pre-qualified Indian and international architecture and planning firms. A committee chaired by the Director of the Institute and including faculty, students and experts was then appointed to engage with the master planners (Figure 2). The assumptions underlying the plans were questioned and thoroughly discussed. Based upon the outcome of these discussions, several different layout possibilities, dispersed and compact, were prepared and presented to the committee before the final compact plan was selected. This compact plan placed the main campus for ultimately more than 4800 students in the southern section of the site and reserved the northern parcel for bio-diversity and future development.

A very lively participatory process was used to develop the Masterplan. Students, faculty and staff were all involved and a large group, led by the Director, met weekly for all-day meetings with the architects and consultants. From time to time, the meeting would include colleagues visiting the Institute from elsewhere, eg., IIT Kanpur and IIT Bombay. Deciding to use one firm (in this case a consortium) for the master planning and other firms for the design of different sectors of the campus (student hostels, academic buildings, staff and faculty housing) also contributed to the lively exchanges as many times all these architects and consultants would be in the same meetings. Such exchanges ultimately resulted in better designs and more stakeholder ownership of the final project.

Figure 2. Masterplan discussion in 2012

Site of new campus, before construction begins

3.1. Site location and characteristics

The site, spreading over an area of 399 acres, stretches for a distance of about 3 km along the western bank of the Sabarmati River, across from the city of Gandhinagar, located in Gandhinagar district, Gujarat (Figure 3). The site is in two separate parcels, with the village of Palaj (together with its 45 m access road to the river) in between. On the eastern side, the new highway forms the boundary to the site as well as to the village. Of the total site area, the southern parcel consists of 305.1 acres; 93.9 acres lie in the northern parcel. Earlier, the land in the southern parcel was being used for forage research. Sand mining is practiced on the river bed and sand is transported via trucks or tractor trailers through ravines in the site. At present the land is lying fallow. There is a temple to the south of the site.

Figure 3. Image of the site before construction, from Google Maps

3.2. Accessibility

The site is accessible from the 65 m wide highway from Shahpur to Lakavada that runs along the eastern side of the site. The nearest airport is Sardar Vallabhai Patel International Airport in Ahmedabad (24.2 km) while the nearest railway station is Gandhinagar Railway Station at a distance of 11.9 km.

3.3. Climate

Gandhinagar is hot and dry for six months and hot and humid for three months while three months are relatively comfortable. The analysis of temperature and humidity shows that cooling is required for most of the year. During the dry summer months humidification is also required.

As per the local newspaper, the Gazetteer, the average annual rainfall in the district is 732 mm and on average there are 33 rainy days in the year. During the monsoon months June to September, especially in July and August, rainfall is heavy and rain protection is required for pedestrian walkways. During the south-west monsoon season, particularly in July and August, the skies are heavily clouded. During the rest of the year the skies are mostly clear to light clouds.

All through the summer, sunshine is intense and buildings and pedestrian walkways need protection from the sun.

Wind is variable but the main wind direction is S-SW-W during the windy months, June to September. The preferred orientation of buildings for wind is SW but this is at variance with the North South orientation that is needed for sun protection.

In the final analysis, the climate is so hot that without cooling systems the buildings cannot be made comfortable through passive structural arrangements alone.

3.4. Topography

The elevation of the site varies from 73.5 m in the south to 82.5 m in the north. The river is located at a distance of 60 m from the site at about 50 m above sea level. The lowest point on the site is 55 m in the ravine located to the west of the village Palaj. The cultivable portion of the site rests on the flatter portion of 74-76 m, which dominates the southern part of the site.

The northern parcel is dominated by two major drainage channels entering the site through a large culvert at its northeast corner and traversing the site diagonally to finally flow out into the river midway on the western boundary. These ravines range in depth from 6 to 10 m or more. Substantial portions of the ravines are below (See Figures 4 to 7) the highest flood level and therefore are susceptible to flooding and backflow from the river extending into the site during the rainy season.

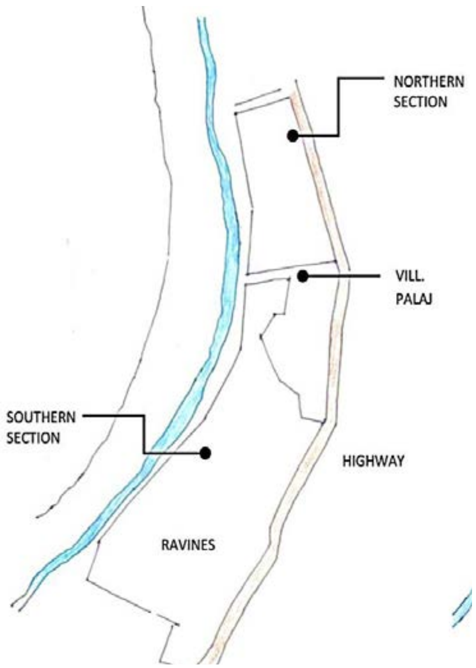


Figure 4. Northern and Southern Sections

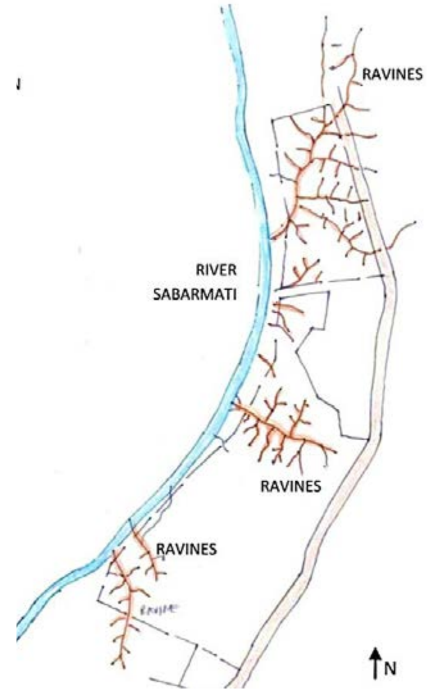


Figure 5. Ravine affected areas (based on Survey map of India)

Figure 6: Survey Plan

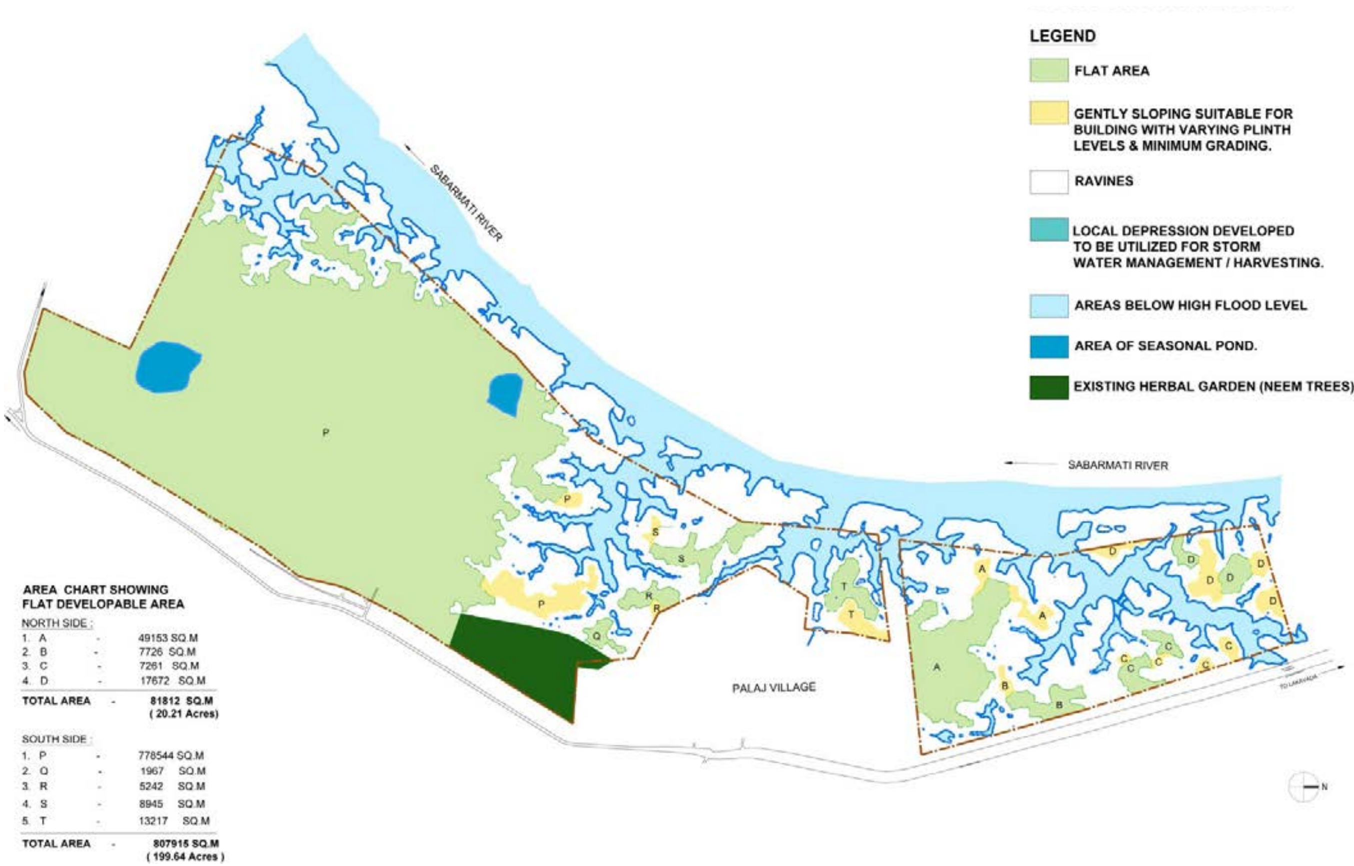


Figure 7: Survey Plan (Slope Analysis)

3.5. Flora and fauna

Fertile agricultural land, severely eroded into ravines at several locations, is characteristic of the existing landscape. The vegetation pattern on-site consists of:

a. Large neem and mango trees found mostly in the flat areas of the site.

b. Ravine thorn forest, with thorny scrub interspersed with neem and acacia, found on the edges and within ravines.

c. The herbal garden area, planted with neem trees.

Neem tree forest on north parcel

4 Guiding Principles for Master Planning

4.1. Planning regulations

The land use for the site was changed from 'Agricultural'/'recreational' to 'Institutional' and the sub-class of Institutional Land Use determined the Floor Area Ratio (FAR) permitted. This could vary from 1 to 1.5 or even more. According to the conditions given in the draft agreement with the state government:

1. IITGN was required to make arrangements for facilitating the flow of water through the ravines.
2. IITGN was required to make arrangements to allow residents of the village Palaj to approach the Sabarmati River.
3. The land was to be used for educational purposes and any other type of use would require permission of the Roads and Buildings Department.

4.2. Building regulations

Important Gujarat Urban Development Authority (GUDA) building regulations that affected the master planning included:

1. The maximum length of the buildings was to be 50 m. A puncture of 7.5x7.5x6 m high was to be provided where buildings were longer.
2. The margins between buildings were to be 6 m between low-rise buildings and 12 m between high-rise buildings.
3. The parking requirement for college buildings are 70 sq m of parking space for every 75 sq m (100 students @ 0.75 sq m per student) of built space.

4.3. Brief

a) Compact design to reduce circulation and service network lengths.

b) Spaces that surprise and entice the viewer non-symmetrical movement that leads to unexpected experiences.

c) Complete and absolute respect for the environment at both micro and macro levels.

d) Respect, conserve and where possible, recycle resources.

4.4. Detail

Road layout

a) The road layout was designed to allow the buildings to follow optimum orientation for sun or wind. This allows minimum heat gain in summers yet direct sun in winters - allowing passive cooling and heating to take place. This helps conserve energy usage.

b) The layout was designed to discourage the use of motorised transport and to facilitate pedestrian movement. This was achieved by restricting staff housing at the periphery to limit the ingression of cars inside the campus. Further the buildings have been placed closer to each other, reducing the need to travel large distances and hence facilitating pedestrian movement.

c) On-site staff housing reduces the traffic generation caused by movement of staff and faculty (from outside campus) to the campus every day.

Landscape

a) Both wild and manicured open spaces have been planned in harmony with each other. While the wilderness of ravines will have a higher ecological value and serve as habitat for native flora and fauna, the manicured open spaces serve as active and passive recreational spaces as well as fulfilling an aesthetic function.

b) Seasonal pools have been retained and used as landscape assets. This helps reduce the urban heat island effect by improving the micro climate.

Buildings

a) Compact building layout.

b) Walk-up apartments further reduce energy needs (e.g. no elevators).

Infrastructure

a) To protect further damage to the ravines, care was taken to minimize discharge of runoff.

b) Infrastructure details and guidelines were meticulously worked out to encourage the concepts of reducing, reusing and recycling resources, thus reducing the ecological footprint of the project, particularly by reducing the site's dependency on city resources.

c) The project is undertaking massive rainwater harvesting to meet water requirements of the campus. This ensures that an in-situ renewable resource is used and less energy is required to bring potable water from the Narmada Canal to the site.

d) The sewage generated is treated on-site. This provides an opportunity to reuse treated water and reduces the demand for fresh water. Further, it reduces the load on the city's treatment system. In addition, it gives an additional opportunity of capturing and using methane gas.

Aerial view of the campus

5 Organisational Principles for Layout Plan

5.1. Three generic ways of organizing university buildings on a campus

The Masterplan authors posited that there are three typical ways in which buildings can be organised on a campus (Figure 8). The first has the cluster of academic buildings as the central focus, flanked by staff residences on one side and the student hostels on the other. The open spaces and common facilities are planned separately. IIT Delhi is an example of such planning.

The second approach is to create a central campus green with all different types of buildings arranged around it. This results in the creation of a theatrical central space.

In the third approach, several different self-contained pockets of academic buildings, hostels and staff residences are arranged around the central green. This is commonly seen in universities with several independent colleges.

The academic buildings for a technical university can also be arranged in three different ways (Figure 8). In the first arrangement, the shared facilities such as lecture theatres and teaching labs are provided in special blocks and different building blocks house the departments. IIT Kanpur is an example of such an arrangement.

In the second arrangement, each department is treated as a separate entity complete with its own lecture rooms and labs. In the third arrangement, the common lecture rooms and teaching labs are stretched out along a linear path and the departments are also arranged along the same path. This method has the advantage that the growth of facilities can keep pace with the growth of requirements. IIT Delhi uses this approach in part.

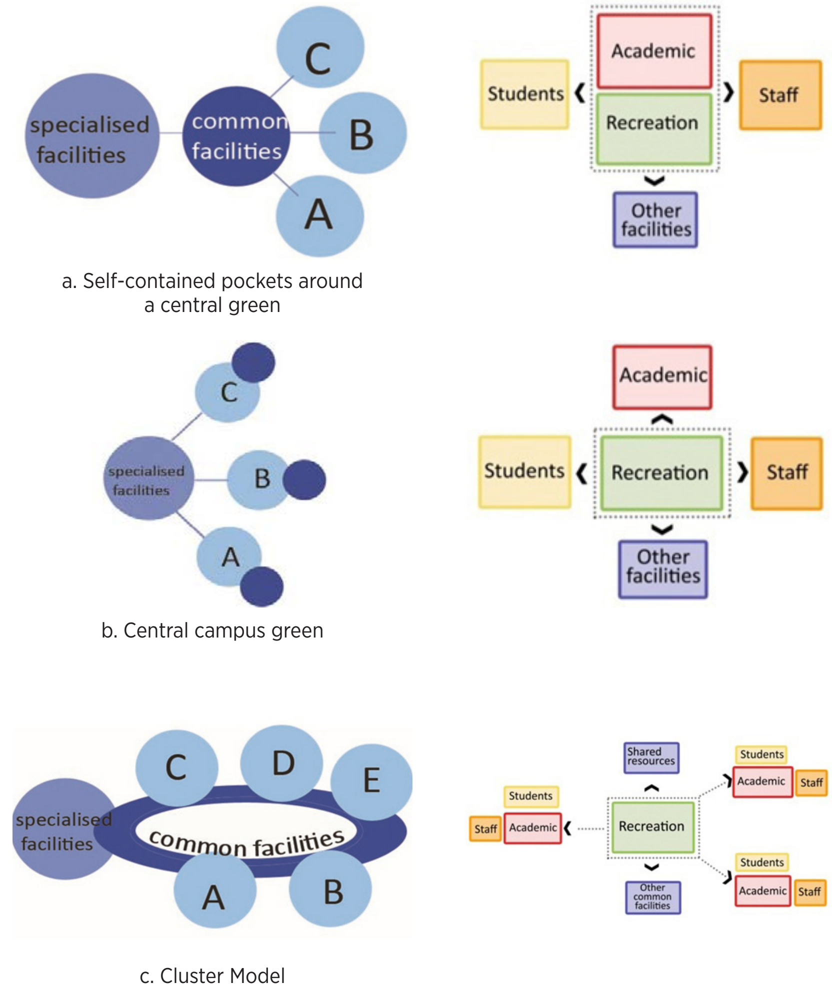


Figure 8. Academic campus organisation

5.2. Building typology

While it is commonly believed that tall buildings utilize land better, the overall requirement of land is actually fairly independent of the height of buildings. Taller buildings require a greater distance between blocks. A comparison of tall and short buildings for academic areas shown in (Figure 9) shows that the land requirement for the academic area as designed with tall buildings for a proposed scheme for the competition on development of the IIT Hyderabad campus is similar to a scheme made with three floor buildings for IIT Gandhinagar. A comparison of hostels with four floor courtyard type of buildings and linear hostels with eight floor buildings (Figure 10) also shows no substantial variation in land used.

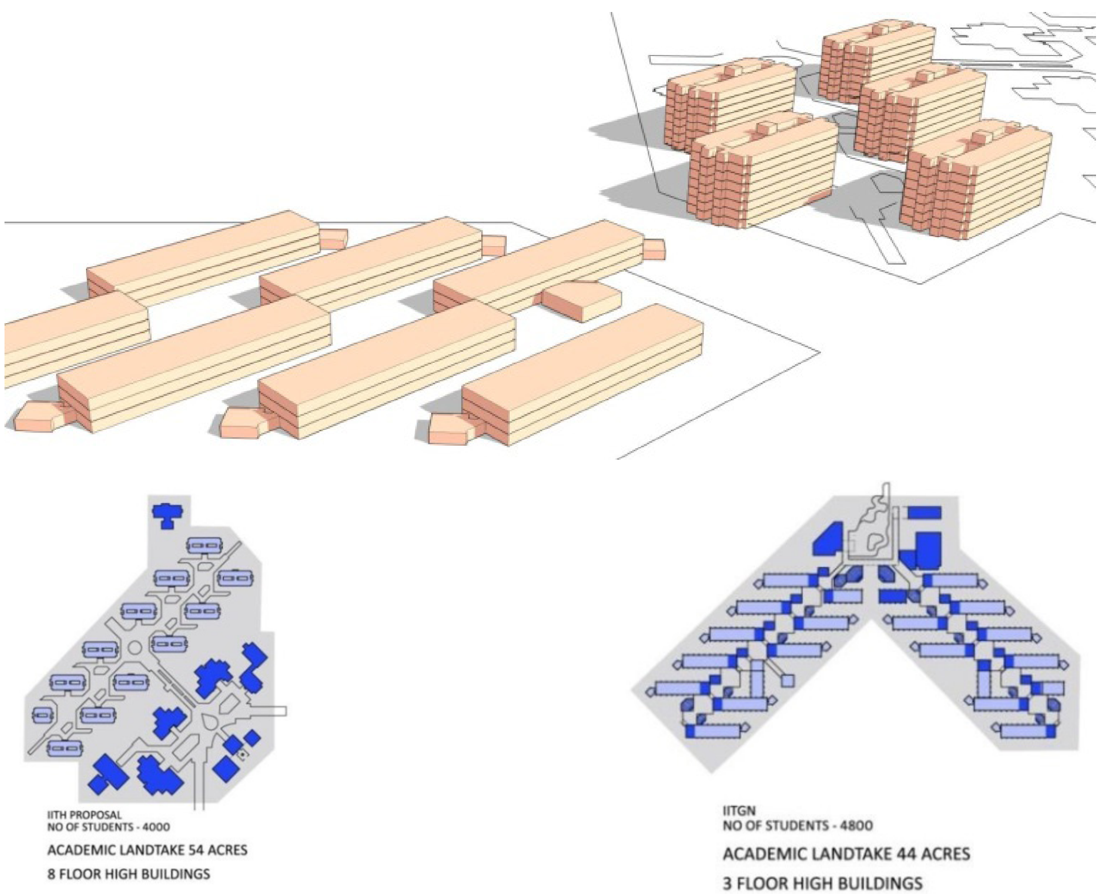


Figure 9: Comparison of academic buildings

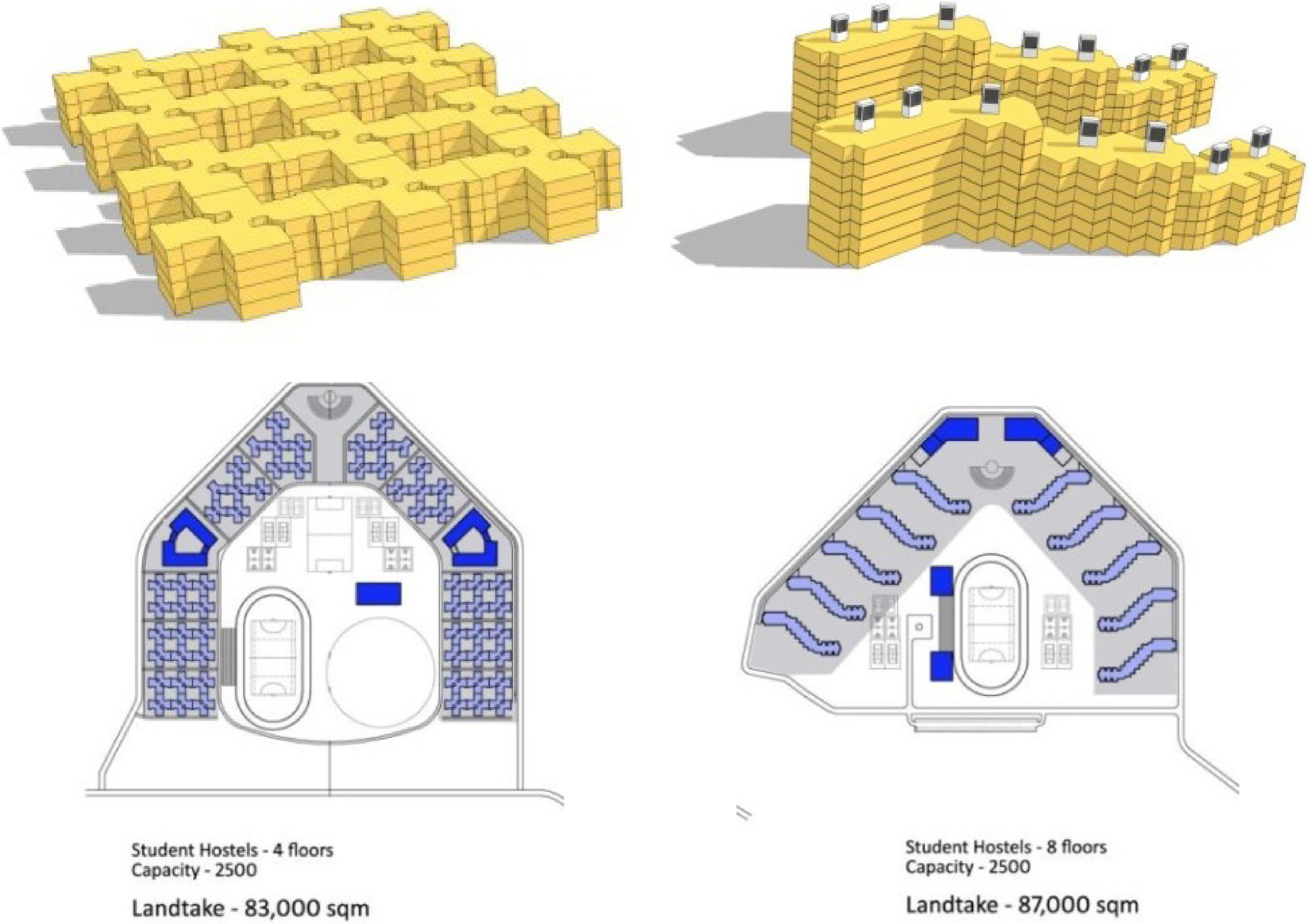


Figure 10: Comparison of hostel buildings

Student hostels

6 Development of Layout Plan

6.1. Plan development

The first layout plan presented during the selection process was conceived as a very compact plan that left about 76 acres of land for future development of the campus beyond a 10,000 student capacity (Figure 11). The southern site was reserved for academic and student residential buildings. All staff housing was located in the northern and middle section of the site.

This layout was developed on the basis of an earlier contour plan of the site that did not show the extent of ravines in the northern section of the site. Subsequent to the assignment of masterplanning, a new contour survey revealed that the northern site had far more extensive ravines. This made housing on the north campus totally unviable. Hence, the student and staff housing both were placed on the south section of the campus. Further, it became clear that a 10,000 student capacity will not be feasible with the available land.

Figure 11: First Layout plan

In initial discussions, it was agreed that the Masterplan for the first two phases would deal only with a population of 4800 students. Since this population could be accommodated in the southern site itself, a new set of requirements were built up for the northern site. In addition to industrial incubators that were part of the original programme, the new requirements included an R&D centre, research park, hospital, school, hotel and a full-scale convention centre. In subsequent meetings it was also decided that more options for the development of the campus should be considered before any layout plan could be finalised. As a result of this discussion, six optional plans were presented. Three of these were dispersed while the others were compact. These were:

- Linear Dispersed
- Radial
- Gurukul Multi Node
- Compact 1
- Compact 2
- Compact 3

Each of these options varied in terms of:

- Disposition of functions on-site
- Land usage
- Total built space
- Urban design controls

Stakeholders in the process pushed to consider alternative options for development, both for the Masterplan design and for the design of individual parcels. Such back and forth, while demanding for the architects to reconceptualize and redraw possible solutions and for the stakeholders who participated in all these discussions, resulted in ultimate design solutions that were more responsive to the variety of stakeholder needs.

6.2. Main considerations

- Create a compact design, reducing circulation and service network lengths.
- Make spaces that surprise and entice the viewer — non-symmetrical movement that leads to unexpected experiences.
- Complete and absolute respect for the environment at both micro and macro levels.
- Respect, conserve and where possible, recycle resources.

6.2.1. Linear dispersed (Figure 12)

- Riverfront promenade concept.
- All academic areas and some hostels strung along the river.
- Promenade will require pedestrian suspension bridges over ravines.
- North side shared between campus and external functions with independent access.

Academic

- Adequate for Phase 3.
- 3/4 floor high buildings.

Hostels

- Adequate for Phase 3.
- 3/4 floor high buildings.

Staff housing

- Just adequate for Phase 2 requirement.

Land assigned for other use (hospital, school etc) – 19.5 acres.

Figure 12: Linear Dispersed plan

6.2.2. Radial (Figure 13)

- Natural green fingers extended into campus.
- Conference centre located for common use by campus and external functions.

Academic

- Adequate for Phase 3.
- 3/4 floor high buildings.

Hostels

- Adequate for Phase 3.
- 5 floor buildings.

Staff housing

- Adequate for 80% of Phase 3 requirement.

Land assigned for other use (hospital, school etc) – 37 acres.

Figure 13: Radial plan

6.2.3. Gurukul multi-node (Figure 14)

- Multi-node design – one node for each phase.
- Students, staff and academic areas located in close proximity.
- Limited interaction between nodes.
- Good for developing separate centres.

Academic

- Adequate for Phase 3.
- 3/4 floor high buildings.

Hostels

- Adequate for Phase 3.
- 4 floor high buildings.

Staff housing

- Adequate for 65% of Phase 3 requirement.

Land assigned for other use (hospital, school etc) – 18.7 acres.

Figure 14: Gurukul multi-node plan

6.2.4. Compact 1 (Figure 15)

- Modification of entry at selection process.
- Hostels close to academic areas.
- Phase 3 development is contiguous.
- Faculty housing is contiguous in north.
- Public transport required for faculty to come to academic areas.
- Substantial land reserve for future development in the south.
- No issues of land take over.

Academic

- Adequate for Phase 3.
- 3/4 floor high buildings.

Hostels

- Adequate for Phase 3.
- 4/5 floor buildings.

Staff housing

- Adequate for Phase 3.

Land assigned for other use (hospital, school etc) – 38 acres.

Hostels close to academic buildings.

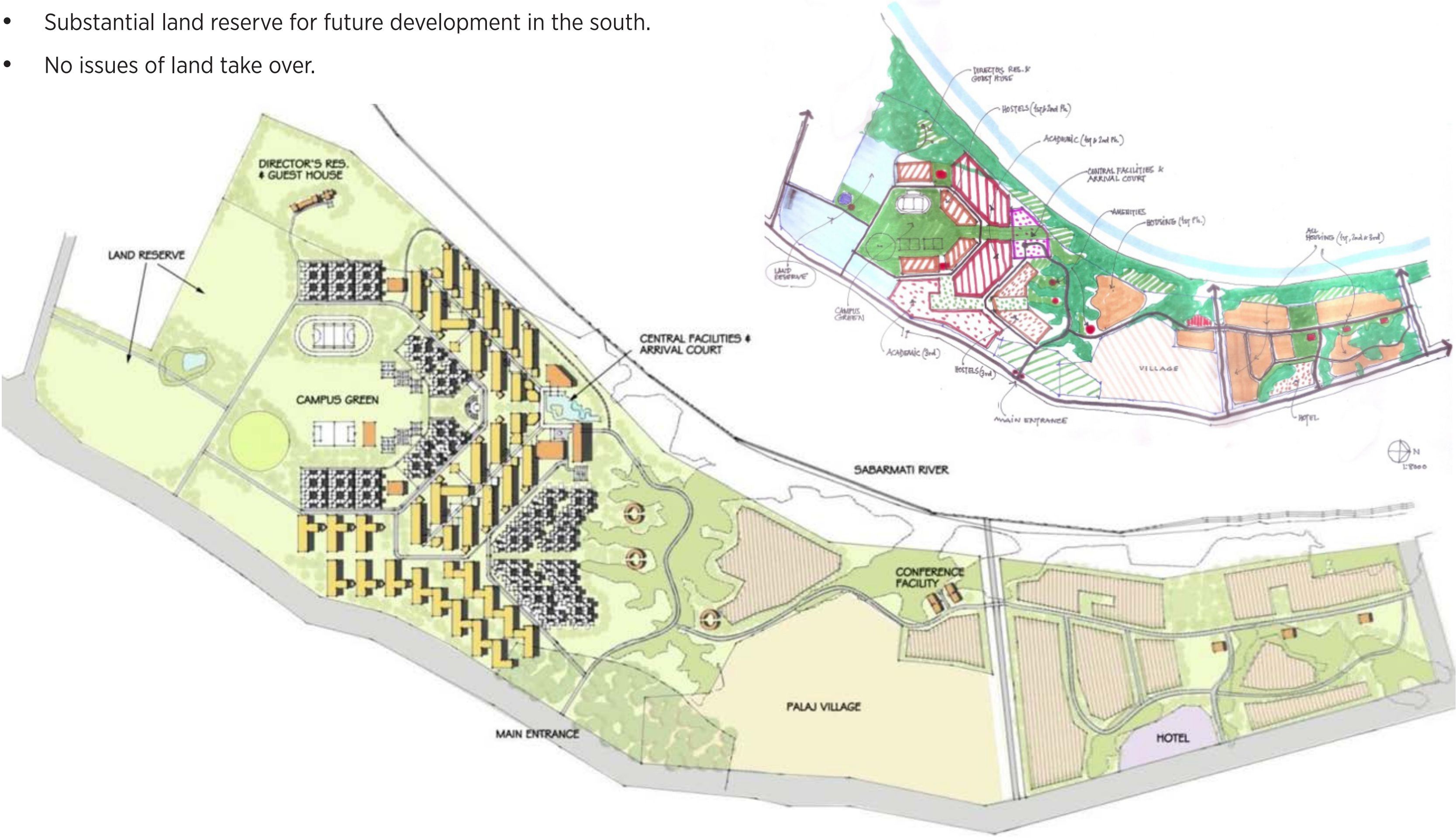


Figure 15: Compact plan 1

6.2.5. Compact 2 (Figure 16)

- Staff housing moved to south side.
- Hostels remain close to academic areas.
- Students and staff share greens.
- Northern parcel reserved for future development.

Academic

- Adequate for Phase 3.
- 3/4 floor high buildings.

Hostels

- Adequate for Phase 3.
- 4/5 floor buildings.

Staff housing

- Adequate for Phase 2 only.

Land assigned for other use (hospital, school etc) – 41 acres.

Figure 16: Compact plan 2

6.2.6. Compact 3 (Figure 17)

- Hostels moved away from academic areas.
- Students and staff share amenities and greens.
- Phase 3 development not contiguous.
- Northern parcel reserved for future development.

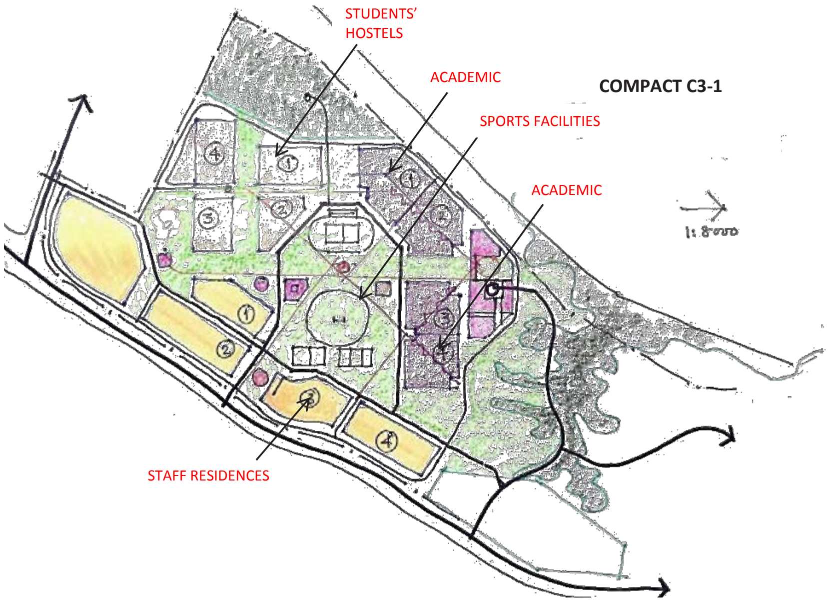
Compact 3 is the plan chosen as best meeting the needs of IITGN.

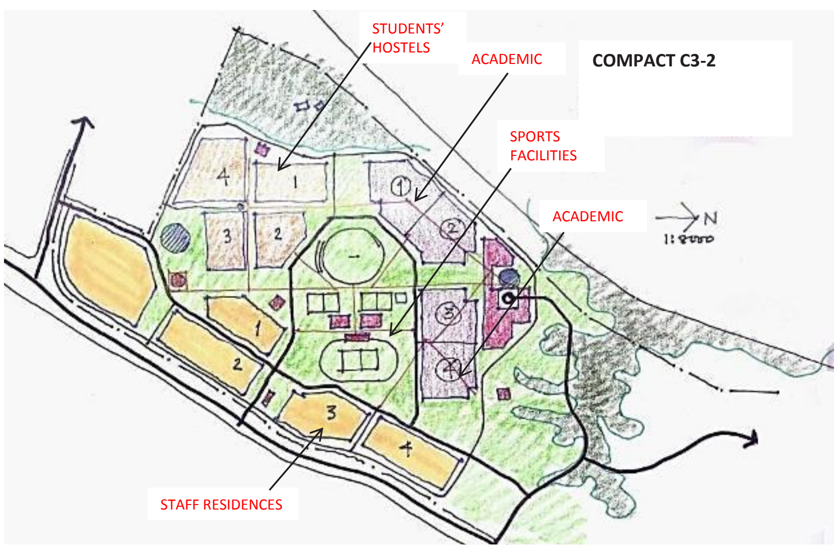
Figure 17: Compact plan 3

6.2.7. Compact 3 options (Figure 18)

Design development of compact options, C3-1, C3-2 and C3-3.

The second topographical survey was completed at the time when Compact 3 option was to be developed. The severely limited availability of usable land in the northern portion required more intensive use of land in the southern portion.





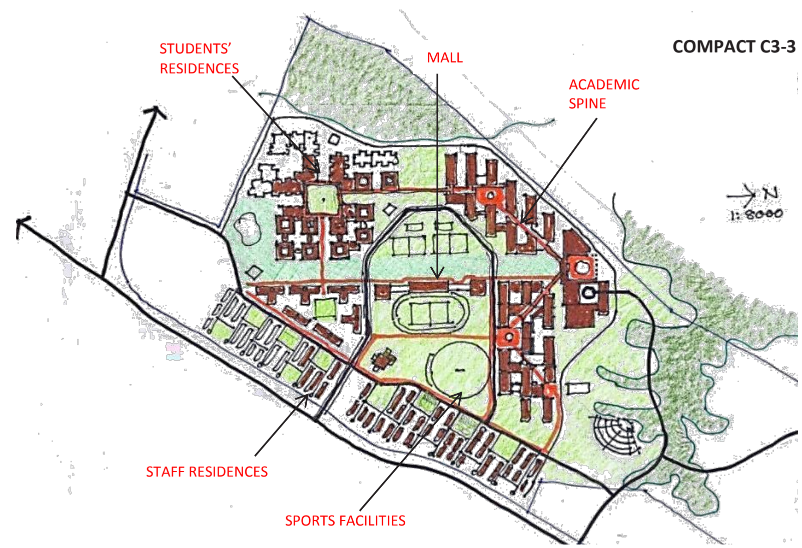


Figure 18: Compact options plan 3

6.2.6. Compact C3-4 (Figure 19)

While option C3-3 has many good features, it does not allow any room for future expansion of campus beyond 4800 students.

A further option C3-4 has been developed that allows growth of academic buildings to about 6000 student capacity, while retaining the important features of C3-3.

Figure 19: Compact plan C3-4

Birds eye view of Academic Complex

7 Urban Design

7.1. Form and space

Once the functional requirements for the site were identified, various basic 'forms' of the campus were examined. These were various combinations of dispersed' and compact' forms of development. A 'compact' option was selected with the idea that a 'compact' form of development offered the best opportunity for creating an outstanding campus: vital, inward and of a human scale. The site is outside the city in a rural area without any existing urban character within and outside the site. The most important feature within the site is its 'ravines' and outside, the Sabarmati River. The proposed Urban Design Concept dwells on these unique features of the site to create an 'image' or a 'sense of place' for the Institute (Figure 20).

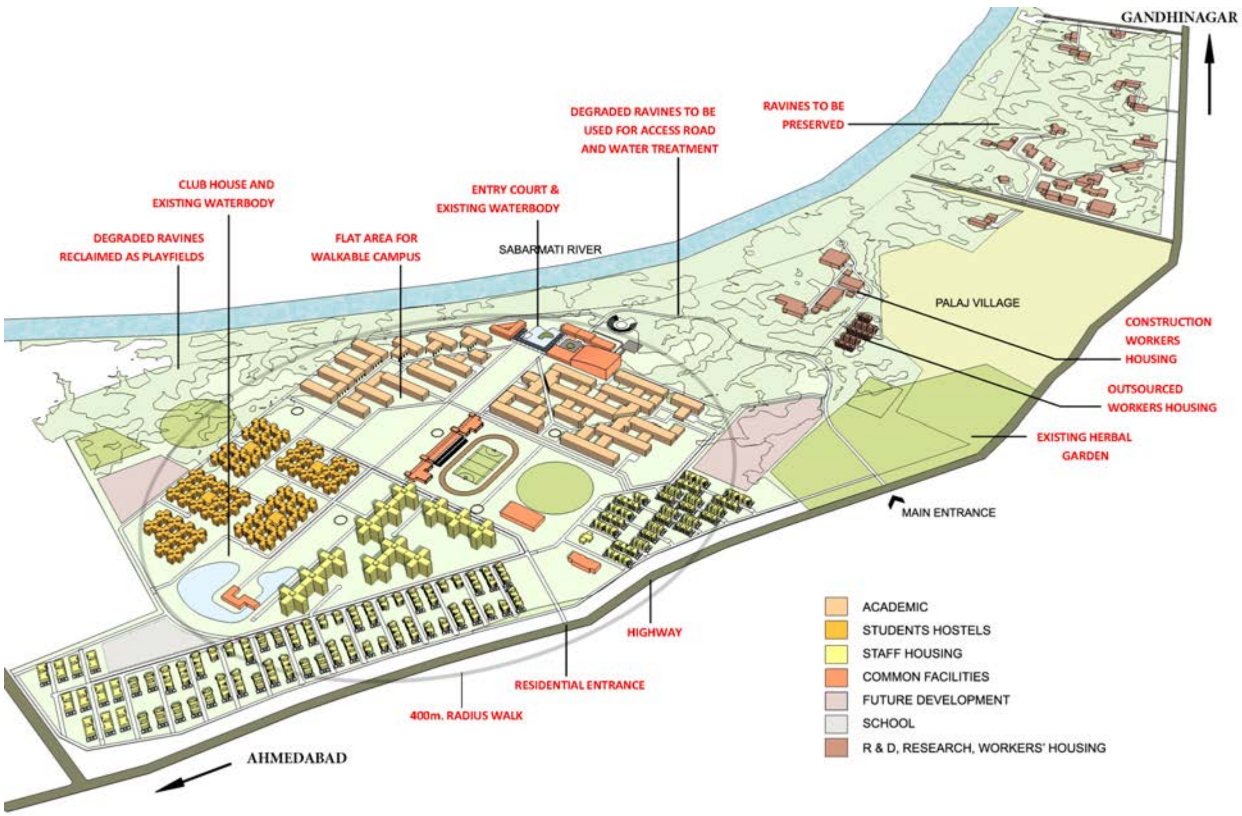


Figure 20: Site Zoning Aerial View

Within the 'compact' concept, a combination of 'clustered' and 'linear' forms of development were chosen. Sometimes the buildings were grouped around open 'courts' and other times arranged along linear 'paths' or 'streets' (Figure 21).

The compact forms of Academic, Residential and Hostel areas have been integrated through the use of open space. A linear open 'Mall' runs through the campus, starting from the academic core and ending at a natural water body between the hostels and staff housing. This 'Green Mall' will be lined with various kinds of activities and is expected to become one of the most 'imageable' elements of the campus. Another open space runs at a right angle to this mall and connects the campus to the river. This space accommodates all the sports facilities of the Institute. At the intersection of these two campus level open spaces, an 'Arcade' has been proposed, housing various amenities for the students and staff. This place will be the 'hub' of all non-academic activities of the Institute and is expected to be a very active, vibrant and popular joint for all.

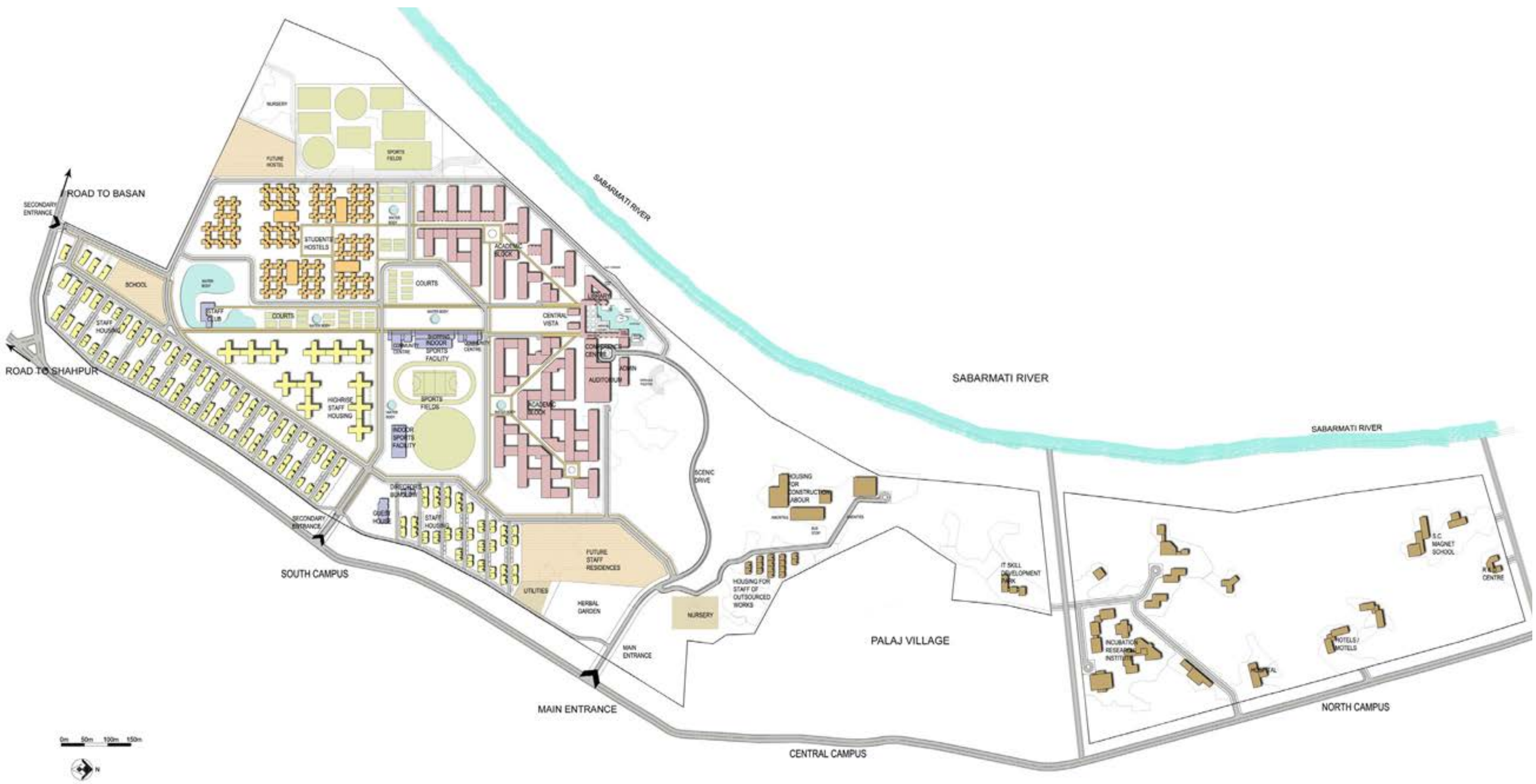


Figure 21: Site Zoning Plan

7.2. Visual character

The visual character of the Institute is defined at two levels. At the overall campus level, the 'theme' is set by the use of gateways, courts, colonnades and water features. This level of character was defined by the Masterplan. At the building level, the architectural style, modular system, materials and colour are used to define the character. This level of character has been defined by the architects designing various complexes of the new campus.

Gateways:

Gateways highlight entries to a place or a building and announce the act of 'arrival'. At IITGN it happens at various levels and in different ways. The 'Arrival Court' at the end of the 'Scenic Drive' is the symbolic gateway to the Institute (Figure 22). At the entry to the academic axes, the building configuration presents an inviting 'gateway' feeling (Figure 23).

Courts:

Courts have been used throughout the campus as 'organising' elements for buildings, as 'positive' open spaces to accommodate various activities and to control the microclimate. The 'Arrival Court' is the symbolic entrance to the campus and it also contains an existing water body. The academic buildings are all arranged around 'courts' of various sizes. All the hostels are grouped around a large court and each hostel in turn has a number of smaller courts accommodating various student activities (Figure 24).

Colonnades:

Important courts, movement spines, arcades etc. are lined by colonnades of various types. Colonnades define public spaces and add distinctive character to them.

Water features:

Water features are extensively used throughout the campus landscape (Figure 25). Not just a visual element, water is also used as a cooling agent. All the water bodies are a part of the water management system. The form and design of these water bodies reflect the local character.

Figure 22: Arrival Court

Figure 23: Mall and Central Vista

Figure 24: Student's hostel

At the building level, the architectural style, the structural system, the material and colour use greatly contribute to the visual character of the campus.

The Spine:

The academic areas of the campus are grouped along two linear spines. These spines are primarily pedestrian movement corridors where different department buildings, lecture halls, common teaching labs, etc. are located (Figure 26). Functionally, besides being movement paths, these spines play a major role in encouraging interaction among students and faculty. Different departments have entrances to their buildings from these spines. Physically, it is not just a long corridor but an interesting place with a variety of open spaces accommodating various formal as well as informal student activities. The space of the spines are modulated both horizontally and vertically in shape and size through the use of courtyards, terraces, and upper level cross overs, etc. (Figure 27). These spines are partially covered at various levels to provide a continuous weather-protected path for movement. The building blocks on the spine are located so that there is always a visual link to the open spaces beyond (Figure 28). The spine as a structure and a shading roof has been made from a variety of materials, including concrete, steel, polycarbonate, fabric and vegetation.

7.3. Urban design and architectural control

The Masterplan intended to strictly control movement, infrastructure and land uses, including the allowable area for development in each parcel.

The design of a few critical features such as the Arrival Court, the Academic Spines, the Arcade and the Hostel Court were controlled by general guidelines in terms of their location, shape and size.

The 'built character' of the campus is derived from the urban design ideas and does not depend on particular architectural expressions of style, material and colour. The Masterplan was developed to accommodate different types of 'architectural expressions' produced by different architects working on various aspects of the project. However certain materials were specified not to be used, including Aluminium Composite Panel (ACP).

Figure 25: Water feature

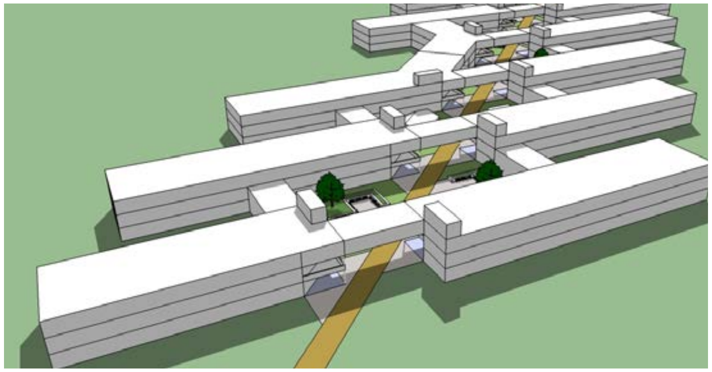


Figure 26: Academic Spine

Figure 27: Academic Spine entrance

Figure 28 : Site layout plan

Inner loop road

8 *Landscape Plan*

The very unique terrain of the campus, which includes the wild and eroded ravines along the riverfront, was used in a creative way to draw visitors to the site and to clearly define the spaces and their uses. By emphasizing the walkability of the site, the scale of interaction becomes more human.

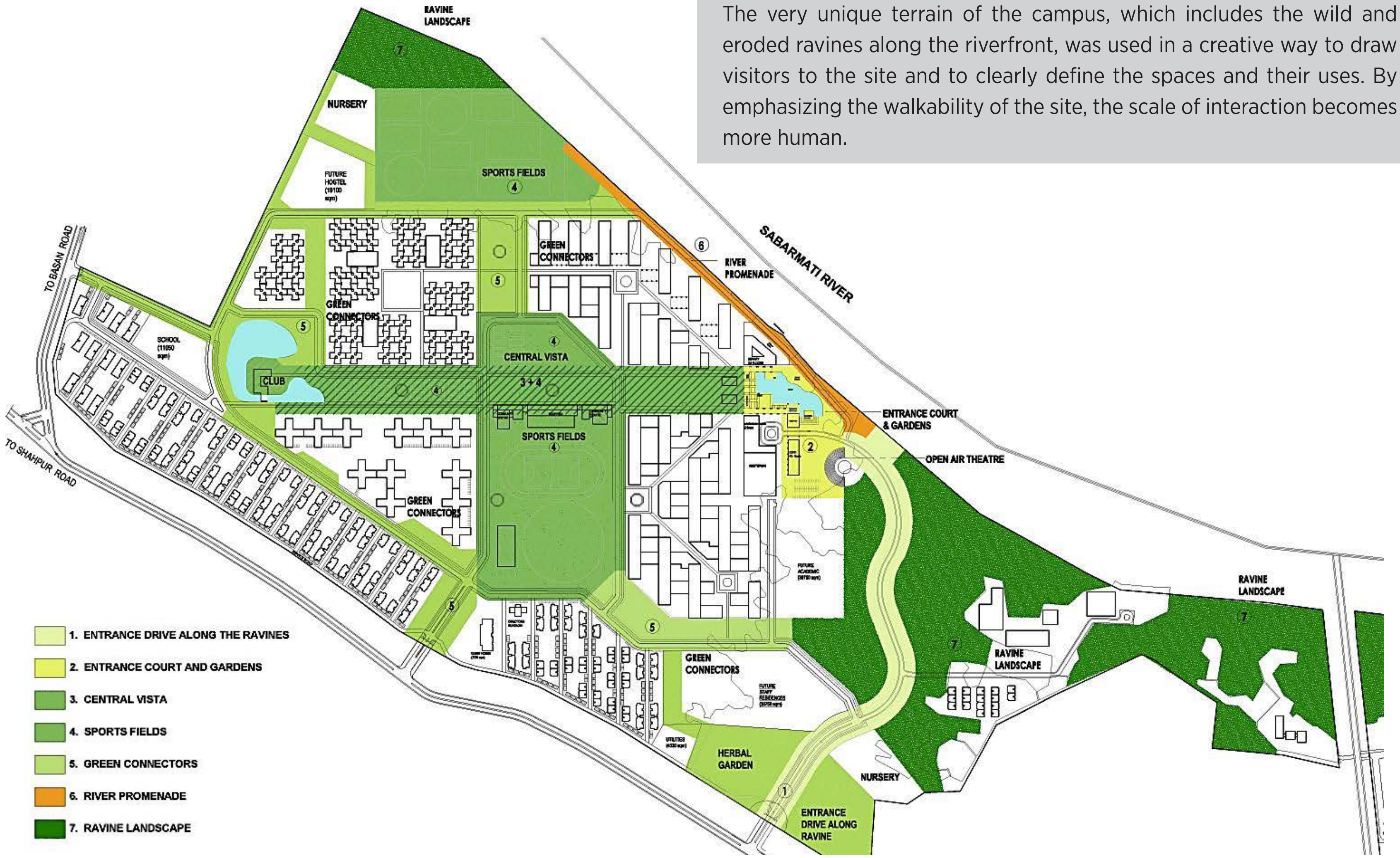


Figure 29: Organization of green spaces

8.1. Landscape structure

The landscape structure has been developed as a series of open spaces arranged as a visually interesting and varied network to facilitate comfortable and unhindered pedestrian movement (Figure 29). Tree-shaded pedestrian footpaths follow the alignment of this open space system, connecting academic, residential and recreational areas not only to each other, but also to the riverfront and to the ravine landscape. The landscape structure is held together by the following three important open space features:

8.1.1 The River Promenade along the western boundary of the site is one of the main conceptual anchors of the open space system. Designed as a broad landscaped walkway for movement along the river front of the Academic Complex, it is also the focus of informal leisure activities of students and faculty (Figure 30).

8.1.2 The Ravines are the subject of land rehabilitation, storm water management and soil conservation through erosion control and new planting. They are the second major anchor of the landscape structure, an extensive area where the existing “natural” identity of the landscape can be protected and enhanced, in contrast to other, necessarily more formal, spaces of the campus (Figure 31).

8.1.3 A Central Vista, in the shape of a landscape mall, is the third major space of the landscape structure and is envisaged as the prime open space of the campus. It is conceived as a broad sweep of open space. 50 m wide and lined with large shady trees on either side extending from the Arrival Court at the northern end to the hotels and staff residents at the extreme southern end.

Figure 30, 31 and 32 illustrate physiographic and other environmental and visual aspects that have guided the process of site analysis from which the landscape Masterplan has emerged.

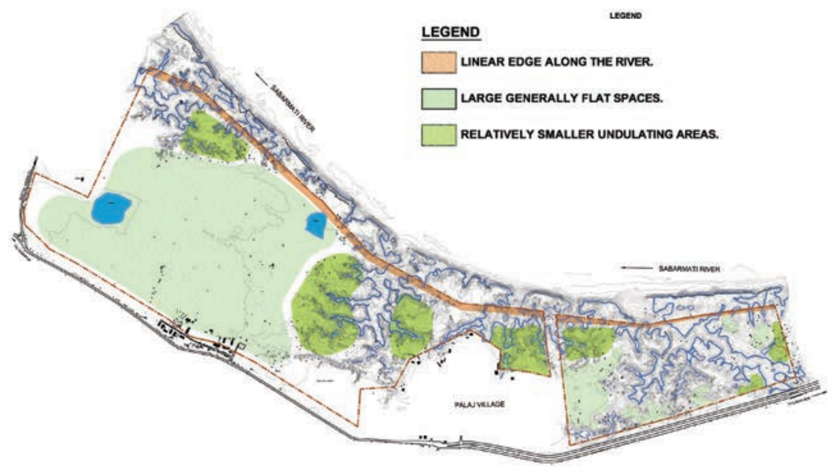


Figure 30: Spaces and visual character

Figure 31: Major vegetation network

8.2. Open space system

8.2.1. The Academic Spine, largely architectural in its definition, consists of courts and connecting arcades between the academic buildings for people to move comfortably, mostly under cover. It is most active during classroom hours, facilitating communication and interaction across departments and buildings and encouraging informal encounters.

8.2.2. Green Connectors are a network of secondary open spaces, chief of which is the residential landscape axis extending parallel to the eastern boundary from the ravine area near the Herbal Garden to the culmination of the Central Vista at its southern end, near the seasonal pond (Figure 32).

8.2.3. Sports Fields were planned at the very heart of the campus, in an expansive meadow-like space, easily seen and conveniently accessible from all parts of the campus. This area is the centerpiece of the landscape structure, to which all other components converge.

8.2.4. Boundary Planting -The site periphery is very extensive and affords the opportunity for major tree planting with species native or hardy in the area. Just the southern section of the site has a periphery of more than 4000 m.

8.2.5. Residential Landscape occurs as avenues and mini neighborhood parks in areas of the faculty residences, and as commonly accessible courtyard spaces at the centre of student hostels (Figure 33).

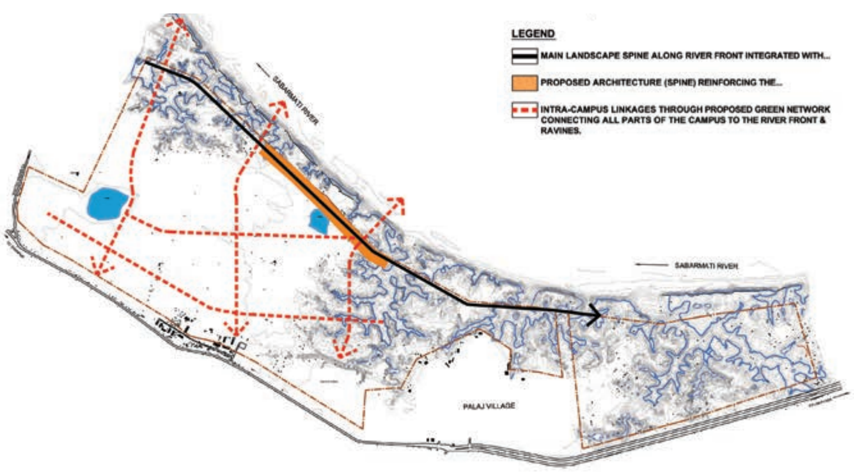


Figure 32: Major linkages and connections

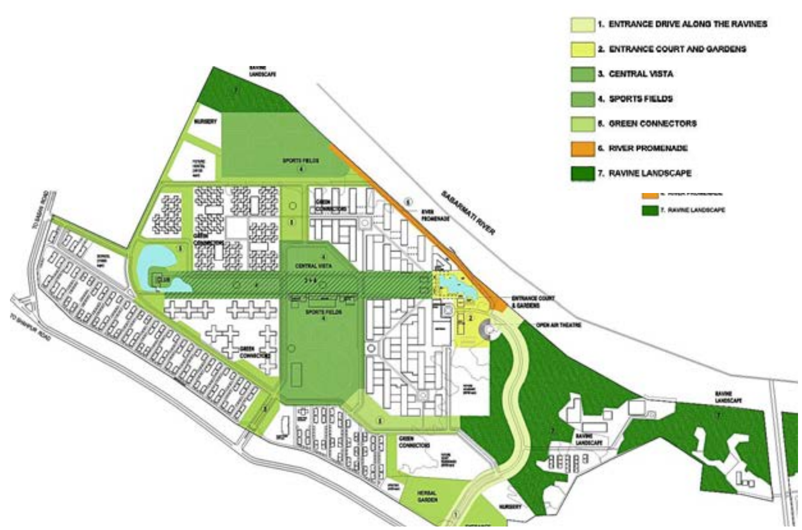


Figure 33: Masterplan landscape spaces

8.3. Erosion control

Implications of flooding of the Sabarmati River and stormwater run-off across the site

A zone approximately 100 m wide on the eastern bank of the river (outside the western site boundary) is highly vulnerable to flooding and erosive processes (Figure 34), which if not controlled will result in the edges of the site itself being adversely affected.

The susceptibility of the zone outside the western edge of the site to soil loss and erosion, as well as back-flow of flood waters into the site via the ravines, are issues caused by factors extraneous to the site, and have to be addressed in the context of administrative and technical governmental measures for flood control. These include:

- Soil conservation on the river edges, for example at the foot of steep banks through the placement of gabions or by grading and stabilizing steep slopes with geo-fabrics or geo-nets and the planting of reeds or other vegetation.
- Curtailment of flood ingress by the construction of earth dams or other measures at the mouth of the ravines. These may be outside the scope of responsibility of IITGN.

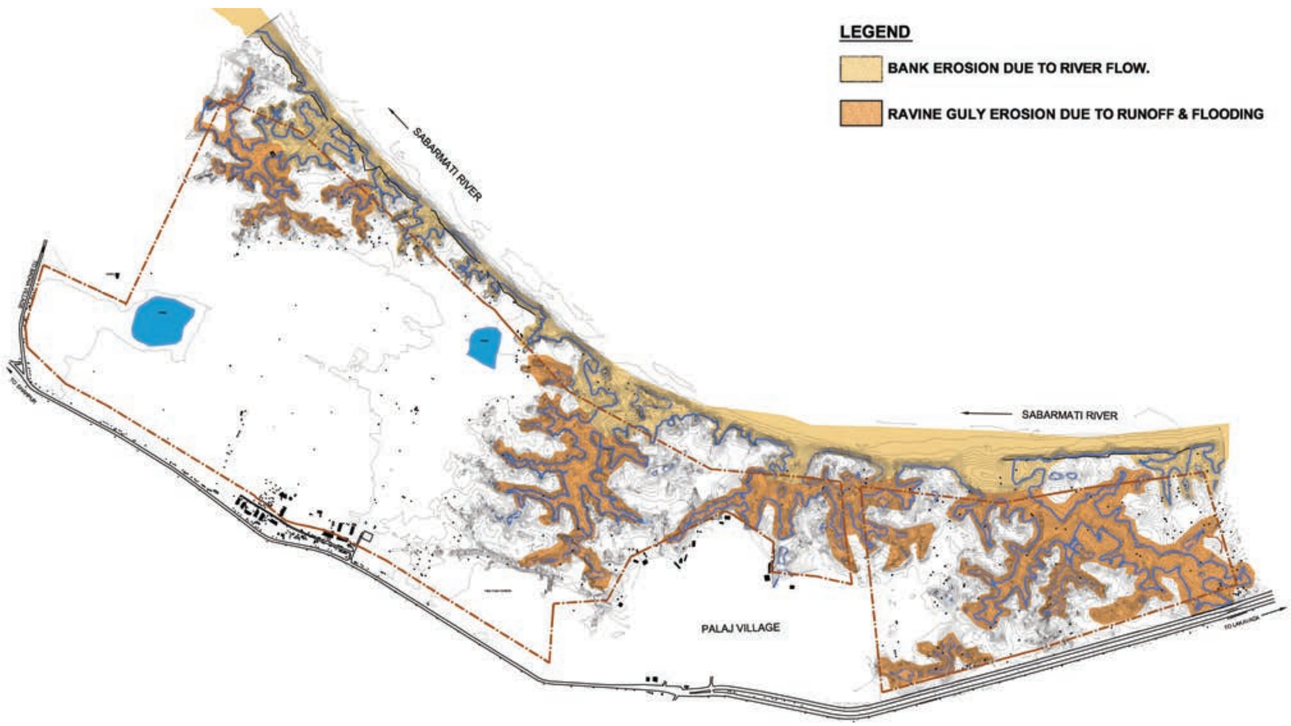


Figure 34: Area prone to erosion

With regard to ravines within the site, particularly in the southern section, once secured from the risk of flooding, action can be directed towards:

- Controlling water flow by the strategic placement of check-dams and other soil-conservation measures, so that they can capture and detain storm-water from the site, for storage and use (See Figure 35).
- Using the ravines for the establishment of root zone beds and constructed wetlands.

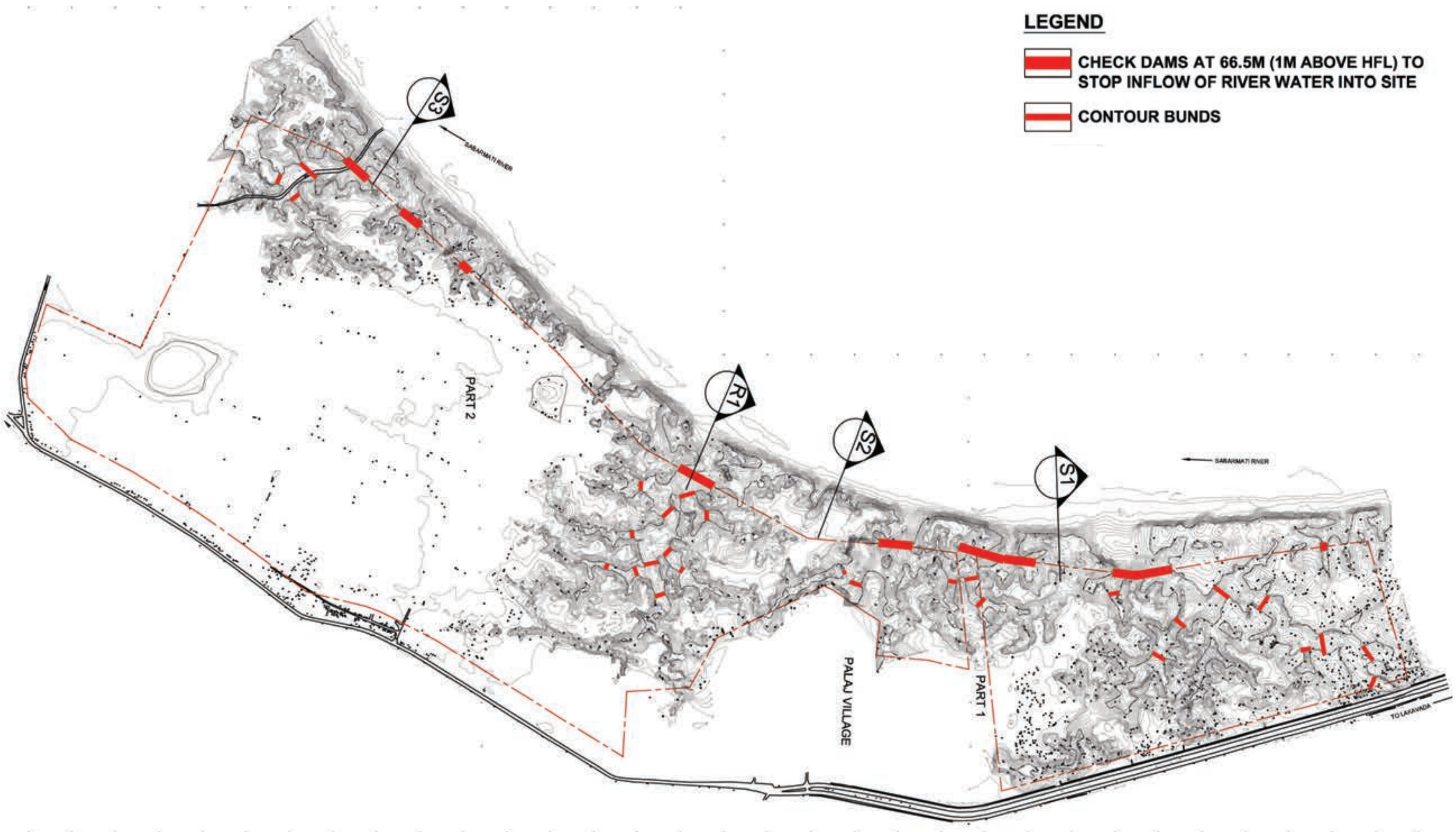


Figure 35: River edge - erosion control and stabilization


Central Vista

9 Infrastructure Design

9.1. Water management system

Water Service Centre

The Masterplan specified creating a facility for receiving, storing, testing, treating and distributing water, to be called the 'Water Service Centre'. Water of different qualities from various sources is brought to these Centres and stored in the reservoirs. Stored water will be tested and subjected to the required treatment and disinfection. The final treated water is pumped into the distribution mains. Three Water Service Centres have been built on campus:

WS Centre-I : Academic Blocks

WS Centre-II : Student Hostels

WS Centre-III : Staff Residences

The decentralized approach helps to keep the distribution mains small, thus simplifying maintenance. The maintenance downtime is short and in case of any eventuality, only a portion of the campus is affected. Any up-scaling of the installation to match with the phased development of any particular zone (Academic, Hostels or Staff Residences) is easier.

Water Distribution

Three qualities of water are distributed on campus (Figure 36):

1) Fresh Water: Water that is taken from sources such as the Narmada River, a lake, tube wells, storage reservoirs and rainwater harvesting systems free from pollution and toxic chemicals and treated to make it fit for human consumption is called fresh water. This water is essentially required for drinking, cooking, bathing, washing, ablution, etc.

2) Recycled Water for Flushing : The water required for toilet flushing does not come in direct contact with the human body and hence, can be of an inferior quality than the one required for drinking, bathing, and washing. The water which has been once used for drinking, cooking, bathing, washing, ablution, etc. can be treated and reused for the flushing of toilets. After some basic treatment rainwater run-off that may not be as pure as that described for fresh water can also be recycled for flushing of toilets.

3) Irrigation Water: Water required for landscape irrigation need not be fresh water. Water once used by human beings becomes rich in nutrients (because of left-over food, human excretions, etc.) and can be used for irrigation after removing the suspended particles.

A unique feature of the campus is its water distribution system, with a separate piping system for each type of water: fresh water from the Narmada River Canal and rooftop rainwater harvesting, and recycled water from the sewage treatment plant. The treatment of sewage is itself unique, passing through anaerobic reactors and a root zone treatment system.

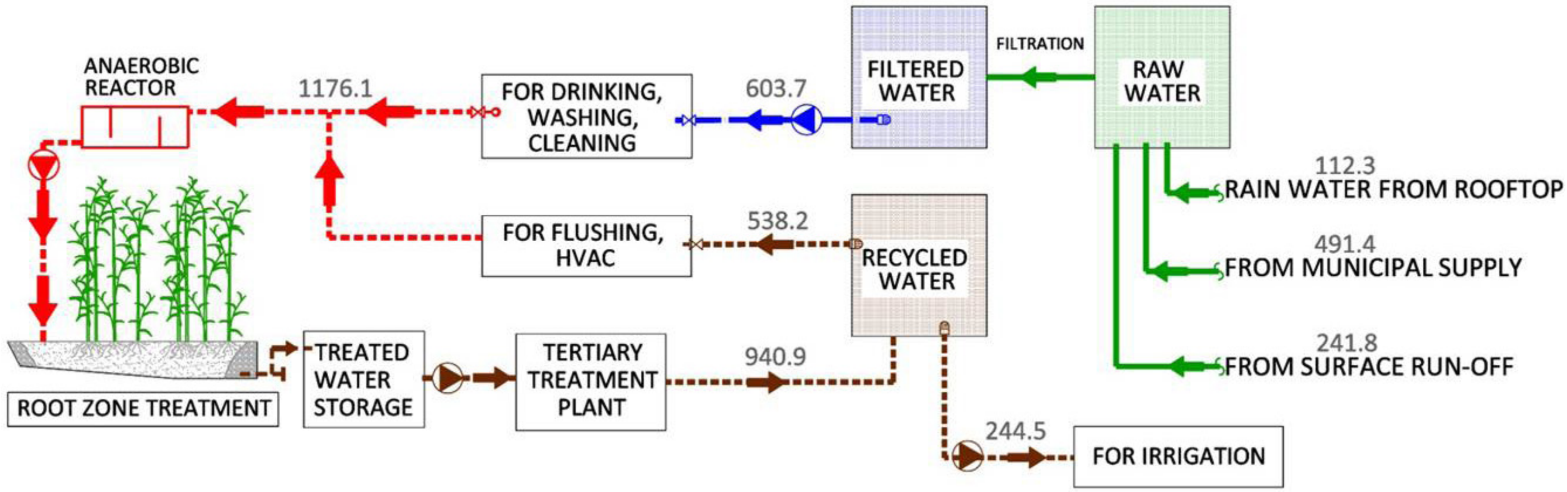


Figure 36: Decentralised Wastewater Treatment System (DEWATS): Water management system on-site

9.2. Sewage Treatment system

Treatment of domestic sewage is generally done through a biological process, mimicking nature at an accelerated pace, i.e. feeding the waste to a bacterial mass which converts the decaying matter into a stabilised basic mixture of water, carbon dioxide and mineral rich residue (Figure 37).

The sewage treatment system for IIT Gandhinagar is based on the following principles :

a) Low energy consumption

b) Minimum use of chemicals

c) Ease of operation and maintenance

d) Ability to withstand variations in flows (during vacation times flows are less)

Anaerobic Reactors on Cluster Basis – The sewage from toilets is discharged into the anaerobic reactors where the solids settle and undergo digestion. The effluent from these reactors overflows into a sewage system. As this effluent is free of large size particles, sewer lines can be laid at a flatter slope than those used by a conventional sewage system that requires a higher velocity to carry away solids in the pipelines.

Constructed Wet Lands / Root Zone Treatment - The root zone system is similar to the one described in the Decentralised Wastewater Treatment System (DEWATS) illustrated in Figure 36 above. The effluent from the anaerobic reactors is collected in a sump and pumped to a root zone treatment system in the existing ravines in the central part of the campus site. The treated effluent from the root zone treatment is pumped to the proposed water service centers, where it is further treated to meet the required standards of ultra filtration systems.

9.3. Solid waste management

General approach for efficient solid waste management

Towards the long-term goal of handling all or most of the waste generated on campus within the campus, IITGN has instituted a host of solid-waste management strategies including waste segregation at source, paper and plastic recycling, energy generation from waste, composting and minimizing landfill waste, minimizing use of disposables etc (Figure 37). At the moment, these collective strategies are helping divert about 1 tonne of waste per day (about 85% of waste generated on campus) from landfills and helping recycle about 1200 kilos of recyclable waste such as paper, plastic, packaging material, and PET bottles per month.

Waste segregation at source is practiced in faculty and staff housing, student hostels and in the academic area. The waste is primarily segregated into four categories; organic waste, recyclable waste, landfill waste and biomedical and lab waste. The organic waste is taken to an on-campus biogas plant that generates energy and manure to be used within the campus. The biomedical and chemical wastes are picked up specialized agencies for appropriate incineration/ disposal.

Waste materials expected to be generated

Glass, plastic, metal, paper and e-waste; Biodegradable wastes from kitchen, horticulture; Construction waste

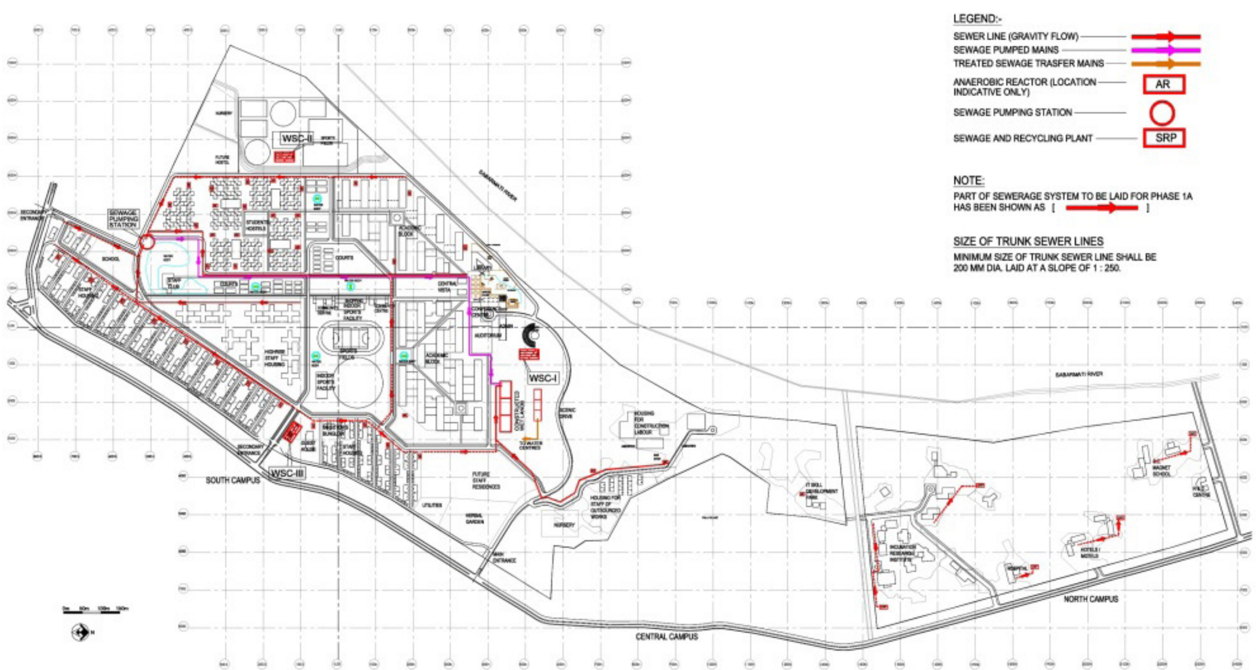


Figure 37: Sewage management system

9.4. Power supply

To estimate the power requirements for the campus the following assumptions were used:

Academic Areas:

Phase-1A	: 45,000 sq m	1200 Students
Phase-1	: 93,014 sq m	2400 Students
Phase-2	: 117,240 sq m	4800 Students

Student Hostels:

Phase-1A	:	1200 Students
Phase-1	: 1.25 kW per students	2400 Students
Phase-2	:	4800 Students

Apartments:

1 BHK - 50 x 6 (3 Floors = 6 Units / Footprint)	300 Units
2 BHK - 83 x 6	498 Units
3 BHK - 11 x 6	66 Units
High Rise - 12 x 28 (7 Floors = 28 Units / Footprint)	336 Units
Total No. of Apartments	1200 Units/6000 Residents

9.5. Communication system

The entire campus IT infrastructure is planned on a fiber optic backbone. This backbone not only provides high bandwidth and high reliability, but also provides a robust backbone into which various IT services such as wired and wireless internet access, IP telephony, building management systems, CCTV cameras, access control, and various other such services plug into. This backbone establishes a foundation for a smart campus that is future ready.

The fiber optics network also supports the IT system management, IT technical support, asset inventory and management, and digital signage.

9.6. Fire alarm system

Most of the buildings are less than 15 meters tall, for which a fire alarm system is not mandatory, except for a few buildings. Wherever a fire alarm is provided, a conventional fire alarm is adequate. Academic buildings and Hostel buildings are provided with a conventional fire alarm system without regard to height because they are public buildings.

9.7. Solar energy

Solar collectors with inverters but without a battery storage system are being used to provide some energy to the Academic Complex and student hostels during the day. The basic parameters are as follows :

- Area required per modules for 1 kW power is 15 sq m land area.
- Area required for modules for 1 MW power is 15000 sq m land area.
- Based on the power requirements in each Academic Block the solar collectors in the various courtyards feed different blocks.
- The capital cost per MW is approximately Rs. 10.00 Crores including the steel structure but excluding the battery.
- The effective solar power is available for 5 to 6 hours, 325 days per year, and will provide 5000 units per day per MW.
- The total load required by the Academic Block (Phase-1A, 1 & 2) is:
    - Phase-1A load : 1000.00 kW.
    - Phase-1 load : 1000.00 kW.
    - Phase-2 load : 2100.00 kW.
- Considering that a 50% load on demand for solar energy is 500.00 kW for Phase-1A the space required for the collectors is 7500 Sq m.
- The same space will be required for Phase-1 i.e. 7500 sq m.
- The space required for Phase-2 will be 15750 sq m.
- The solar power generated will be connected to the grid, and IITGN will receive credit for the same number of units by the electrical authorities at the prevalent tariff. The power received by the authorities will have a higher tariff. This needs further discussion with the authorities.

Sewage Treatment Plant

10

Sustainable Design

10.1. Elements of green campus design

Green campus design in India, in fact the world over, is a poorly understood area. While the issue really ought to be about sustainable campus development (Figure 38), it is often confused with green building certification. Four new standards have emerged recently:

- 'Approach to Sustainability' has been added to the National Building Code of India.
- IGBC Green Township Rating System.
- GRIHA guidelines for Green Large Area Developments.
- The Energy Conservation Building Code.

Figure 38: Sustainability Management Diagram

10.2. Land use

The carrying capacity of the campus has been determined by the permissible Floor Space Index (FSI). IITGN will not be able to use all the FSI as large green areas are needed for recreation. In addition, substantial portions of the site include the ravines that need to be conserved.

The mandatory requirements for green certification have been met and IITGN become the first campus to be awarded a 5 Star Rating by Green Rating for Integrated Habitat Assessment (GRIHA).

10.3. Socio economics

One way in which the relationship with Palaj village has been handled with sensitivity is in the boundary wall between the campus and the Palaj village. Early on in campus development it was decided that it would be necessary to build a boundary wall to delineate the village from the campus. In order to not offend the villagers, however, it was decided to build a low-rise, unobtrusive wall, so villagers might be able to cross the wall easily so as to enter the campus premises. This will ensure that they could continue to enter the area that they have had access to for decades, and yet they will start to recognize the line from which IITGN properly starts. The foundations for the boundary wall were designed for the full height wall so that in case a need arises in the future, IITGN could add height to the wall. The current low-rise wall gives the message that both village and campus can co-exist.

During the first phase of construction, there was a lot of emphasis on worker welfare and safety. Nurseries were provided for very young children so they had a place to go while their parents worked, workers were required to wear hard hats (with some evidence that this increased the quality of workmanship), and they were provided with very good masonry housing on-site.

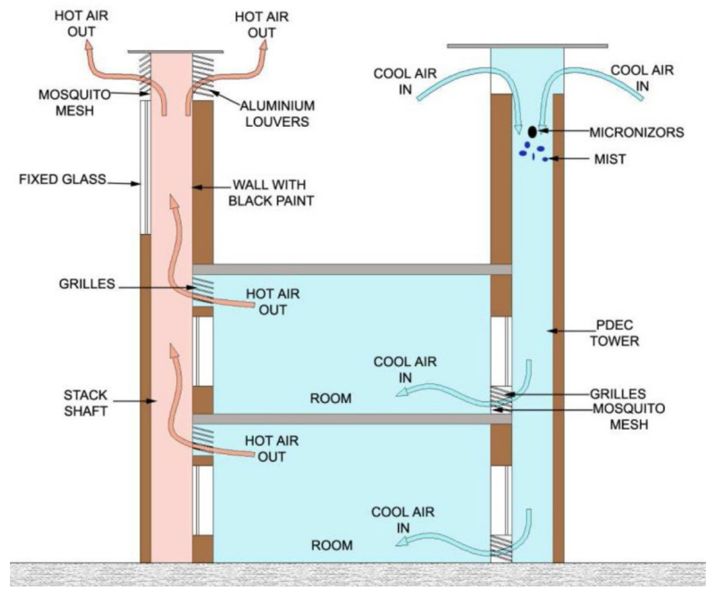


Figure 39: Passive cooling method

10.4. Energy efficiency and renewable energy

While energy efficiency is primarily a building specific issue at the campus level, the major goal is to reduce the use of vehicles to and from, as well as on the campus. The campus layout has been designed to encourage walking and to discourage vehicular use. As the north site is developed further, an electric bus service may be used. The main modes of transport on the campus are walking and bicycling.

Figure 40: Light shaft section

The hostel dining halls and several classrooms in the academic area have been installed with passive downdraft evaporative cooling systems (Figure 39). These systems spray a fine mist of water at a height resulting in cooling of air (in dry weather), and this heavier cool air flowing down to the classrooms or dining halls under gravity. These systems use no fan or power expect for to springing a fine mist of water, and are effective for a warm and dry climate such as in Gujarat for a few months in the year. The energy consumption is therefore drastically reduced. These systems are also supplemented by night purge systems, cavity walls, passive shading devices, use of natural daylight, and insulation (Figure 40).

10.5. Water and waste water management

The efficient use of water is important at both the building and site level. The intent is to harvest rainwater and use it in the buildings. Waste water is being treated through anaerobic bio-reactors and through constructed wetlands (vertical flow) (Figure 41). This system is very energy efficient and it makes use of the space available in the ravines. Treated effluent is used for landscape irrigation. The plant material selected for the landscaping is water conserving.

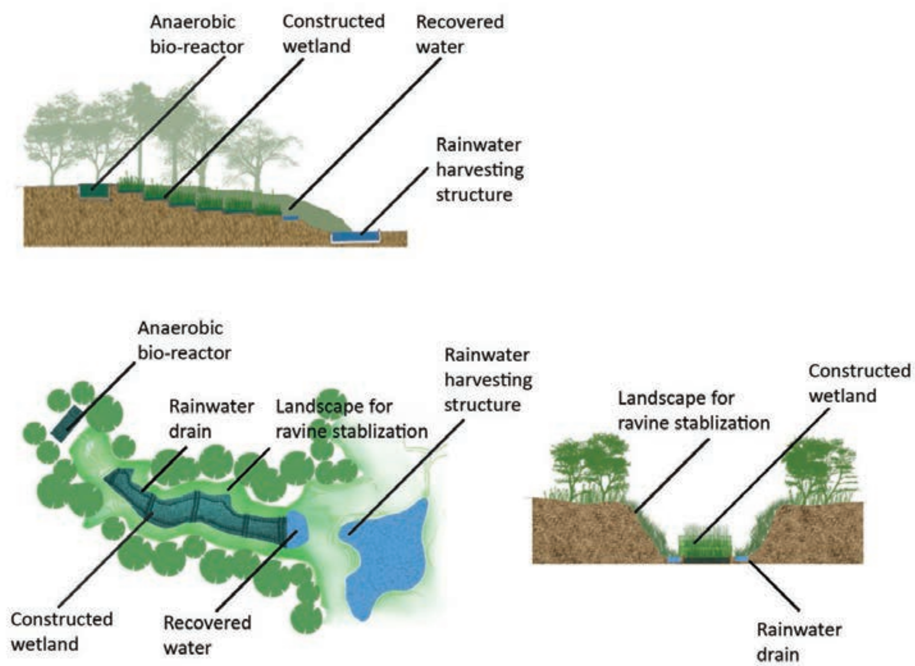


Figure 41: Constructed Wetlands

Harvested water retaining structures are an important functional and visual element of design on the campus, as are the Water Service Centres. Another source of water that is being exploited is flood water that naturally comes into the lower reaches of the ravines on-site. Harvested rainwater and collected flood water can be used for all construction-related water requirements of the site.

10.6. Solid waste management

The solid waste management system has been designed to allow on-site recycling of biodegradable materials and the transfer of recyclable materials to regional commercial recycling centres.

The waste generated during the construction phase is being used on-site to fill designated isolated pockets of land within the site.

10.7. Facility maintenance

The campus requires maintenance and has outsourced this service. However, on-site facilities have been provided for storage for material to be recycled and/or transferred to designated off-site facilities, as well as a maintenance workshop and maintenance material stores.

10.8. Monitoring and control

The campus of IITGN has many different systems for the management of energy, water, daylight, ventilation and cooling systems. The different systems are connected by an Automated Monitoring and Control System. In the initial stages, the system generates primary data that will be used for further optimization at later stages of development. It will also provide an automated control facility.

The campus has a fibre optic network that allows all buildings to be connected by the Automated Monitoring and Control System, thus making IITGN a smart campus.

10.9. Adaptation/ risk mitigation for climate change

There are two elements of climate change that may require adaptation at IITGN: increase in temperatures and change in precipitation patterns. The system of Passive Downdraft Evaporation Cooling (PDEC) should provide relief from higher ambient temperatures and eliminate the need to resort to air conditioning in non-air-conditioned areas of the campus. For changes in rainfall and water availability, large water storage structures will allow the campus to adapt to short-term disruptions in water supply.

A distinctive element of one of the academic buildings, Building 7, was suggested by the Masterplan's recommendation to use architectural design features to help cool the buildings and to monitor the effectiveness of various approaches. Building 7 has a building management system in place that will allow campus staff to monitor the various cooling techniques that are being used in that building over time. In the future, these data can be shared with researchers and designers and used to help determine which techniques might be most appropriate and effective for future buildings.

Building 1 in Academic Complex

11 Implementation of Masterplan

The development of the Masterplan for IIT Gandhinagar was completed in 2012 and construction began at the site in 2013. It was in July 2012 that IITGN appointed three architectural firms-- Mitimitra Consultants, HCPDP, and Vastu Shilpa Consultants-- to work on the academic, student hostel and staff residential buildings, respectively. HCPDP were also appointed to look after site development work. During the initial phases of planning the architectural work, GCDC was involved in assisting IITGN to ensure a good match between the intent of the Masterplan and its implementation. IIT Gandhinagar's "owner's architects" Design and Planning Counsel of Ahmedabad, also played a key role in ensuring the vision of the Masterplan was interpreted successfully by the various project architects. Some minor changes in the Masterplan layout were made in order to account for special site features that were not adequately clear from the survey plan. Prof. Mohammad Shaheer was appointed to advise IITGN on the overall landscape planning design.

The planning of services was a little more complicated as they involved several unexpected challenges. The main entry road passing through the ravines was a difficult civil engineering project. Other works within the ravines such as the root zone treatment system for sewage and housing for construction labour also involved major challenges.

The most difficult part of the site lies along the Sabarmati River and is prone to erosion in times of flood. Protection of the site from erosion requires embankments to be built in areas that lie outside the site of IITGN and fall within the purview of the flood control department. This remains an area of concern.

The purpose of the Masterplan for IITGN was to enable different architects to work on different parts of the campus but all within the unifying vision of the entire campus provided by the Masterplan. The initial set of buildings have been built at the site and it is now expected that new teams from IITGN and new architects will continue the work into the next stage. The robustness of the Masterplan will be tested when these new teams take over. It is hoped that the measures to ensure continuity will work at that time.

Lal Minar, looking towards hostels

12 Project Implementation and Construction Challenges

The initial set of construction, including housing, hostels and the Academic Complex, is now complete, and this addendum briefly highlights some of the major innovations and challenges in completing such a large and challenging project. Table 2 summarizes the basic elements of this construction project and associated costs.

Table 2: Summary of Campus Construction

Description	Brief of Structure	Cost (cr)	Date of Start
Housing	270 units, (G+2) 49,270 Sq m	105	June 2013
Hostels	1225 students (G+3) 35,943 Sq m	68	Aug 2013
Academic Buildings	Laboratories, faculty rooms, class-rooms (G+2) 45,200 Sq m	132	Aug 2013
External Infrastructure	Water Supply, Sewerage, Roads, RWH	52	May 2014
Electrical & Mechanical Services	HVAC, Firefighting, Lifts, E.S.S. & LT Distribution, D.G. Set, WTP, STP, Passive cooling, LED Lighting	46	May 2014 Apr 2015
Specialized	Modular kitchen, Acoustic and Interiors	22	Feb 2015
New Technology	Audio, Video, ELV (Data networking, CCTV, BMS, Access control, Fire Alarm, UPS)	30	Apr 2015

The construction project was managed by the Central Public Works Department (CPWD) of the Government of India. In September of 2012 there were 3 CPWD engineers assigned to the project who actively participated in the campus planning process with the architects. By November 2013 there were 15 CPWD engineers working on the project. It was their job to coordinate what, ultimately, were 23 different construction contracts with different organizational cultures, and to translate the vision of the Institute and the architects through to the actual construction. CPWD and IITGN very actively collaborated in this, working as partners and sharing ideas and strategies for accomplishing some of the unique features of the project.

There were nearly 2500 trees at the site when construction started. Out of these fewer than 150 have been cut with requisite permissions from the appropriate state authorities, 75 neem trees were transplanted along the boundary (out of which 56 have survived and now in full bloom) and 90% of the trees have been kept intact through careful siting of the buildings.

While the construction was in progress during 2013-2015, nearly 15,000 trees of native varieties such as neem, pipal, gulmohar, kadam, areca palm, bauhinia, kashid, arjun etc. were planted on the campus. Land pockets to be developed after a few years have been developed in 2016-17 as green pockets by planting about 750 fruit bearing trees such as chikoo, pomegranate, guava, custard apple, lemon, etc.

CPWD participated in each of the Tuesday meetings with the architects, starting in August 2012, and chaired by the Director himself. Thirty-seven such meetings were held, starting at 9 am and sometimes going until 9 pm or later. Meetings continued to be held with all the stakeholders until construction was complete, although the frequency was reduced later.

The faculty and staff housing and the student hostels were designed and built using confined masonry technology, the first large-scale application of engineered confined masonry in India. Confined masonry was chosen for the project because of its superior performance in earthquakes and a lower cost compared to using RC frames for similar buildings. However the fact that it was a new technology meant that IITGN had to push for its use as it is not covered by existing codes, and the engineers and contractors were not familiar with the typology. The technology uses the same basic materials found in unreinforced masonry construction and RC frame construction with masonry infills but with a different construction sequence and system. The fact that it was a new technology also meant that CPWD had to provide additional training for masons. A large number of bricks were needed for these two housing complexes and CPWD could not find a source that could provide the quantity and quality needed. The bricks needed to provide at least 9 MPa of strength and a water absorption rate of not more than 15%. After a certain amount of consideration, CPWD decided that a brick plant be built on-site to generate the quantity and quality of bricks needed. Thus during the height of construction 65,000 bricks were made on-site each day, with 10 MPa and a water absorption rate of 12%. The use of this technology resulted in significant cost savings over RC frame construction and has brought more attention to the potential for this technology in India. IITGN received first prize in the Housing and Urban Development Corporation Limited (HUDCO) Design Awards 2015 for the use of this technology in the construction of the Institute's staff and faculty housing and student hostels.

In addition to the use of FALG bricks for the housing, lime cement mortar was used for the confined masonry work. The practice of using such mortar in India was stopped a long time ago; thus CPWD had to do a certain amount of reeducation with the contractors to use such mortar.

At the peak of construction there were 2700 workers on-site for five months, coming from nine states across India. 10.5 million man hours went into this construction project. Special conditions were put in each of the tenders, including that each contractor was required to provide a certain number of housing units of given specifications for their construction workers. In addition, IIT Gandhinagar appointed a safety officer whose responsibility included training and safety of all these workers.

Figure 42: FALG brick plant at IITGN

CPWD was also responsible as project managers for the campus infrastructure. Service corridors for the needed pipelines were limited because of the difficult terrain in much of the campus area. Hence, pipelines were laid in multiple layers in the same trenches. There are 60 km of services pipelines on the campus site, 20 km of electrical pipeline and 40 km of water and sewer pipelines.

The 180 acres of deep gullies and ravines presented particular challenges in the construction, both in terms of the location of the academic buildings and the scenic drive and infrastructure through these ravines. The design of one of the academic buildings, Building 4, had to be modified as the building's foundation proved too close to unstable ravines. Building 9 was built very close to the ravines and required additional protection after the heavy rains of 2015.

There were some additional challenges in implementation of the project that surfaced with these rather heavy rains in 2015. The rains caused settlement and soil erosion in the ravines, resulting in substantial damage to some of the service lines and manholes, with a subsequent need to

Figure 43: Construction workers during construction of Academic Complex

replace or shift these lines. Some protection measures had to be put in place in these ravines to minimize this soil erosion. In one instance, the alignment of a road itself was adjusted in view of soil instability caused by the rains. Some temporary open drains were provided to avoid muddy water flowing onto roads and other developed areas. Some protection was also added around Building 9 as it is very close to the ravines.

An additional critically important feature to project implementation was the sense of social responsibility taken by IITGN during the construction phase and now ongoing as IITGN takes up its role to nurture and empower its own and neighbouring communities. During the first phase of construction, emphasis was placed on worker welfare and safety. This sense of responsibility has carried through in campus activities, and in 2014 IITGN established Nurture and Empower Entrepreneurial Ventures (NEEV) to provide entrepreneurial training and livelihood generating activities to local villagers.


View from Academic Building 2

Pathway near Faculty and Staff Housing

13 Credits

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Owners Architect	Mr. Shobhit Tayal, Design and Planning Counsel Pvt. Ltd., Ahmedabad
Owners Engineer	Mr. A. K. Kothari, Superintending Engineer (up to 28-01-2013)
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	Prof. Ashwini Kumar, Civil Engineering
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	Prof. Jaison A. Manjaly, Humanities and Social Sciences
	Prof. Supreet Saini, Chemical Engineering
Master Planner	**Green Campus Development Consortium, New Delhi**
	A consortium of Space Design Consultants, New Delhi and Upalghosh Associates, New Delhi
Project Leader	Dr. Vinod Gupta, Space Design Consultants, New Delhi
Urban Designer	Mr. Ujan Ghosh, Upalghosh Associates, New Delhi
Landscape Design	Prof. Mohammad Shaheer, MSYK Design, New Delhi
Plumbing	Mr. Mukesh Asija, Krim Engineering Services Pvt. Ltd., New Delhi
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Thermal Design	Mr. Sameer Divekar, DbHMS Consultants Pvt. Ltd., Noida
Project Management	**Central Public Works Department (CPWD), Government of India**
Project Manager	Mr. L. K. Bhargava, Superintending Engineer (up to 29-01-2016)
	Mr. Kapil Deo Narayan, Superintending Engineer (from 29-01-2016)

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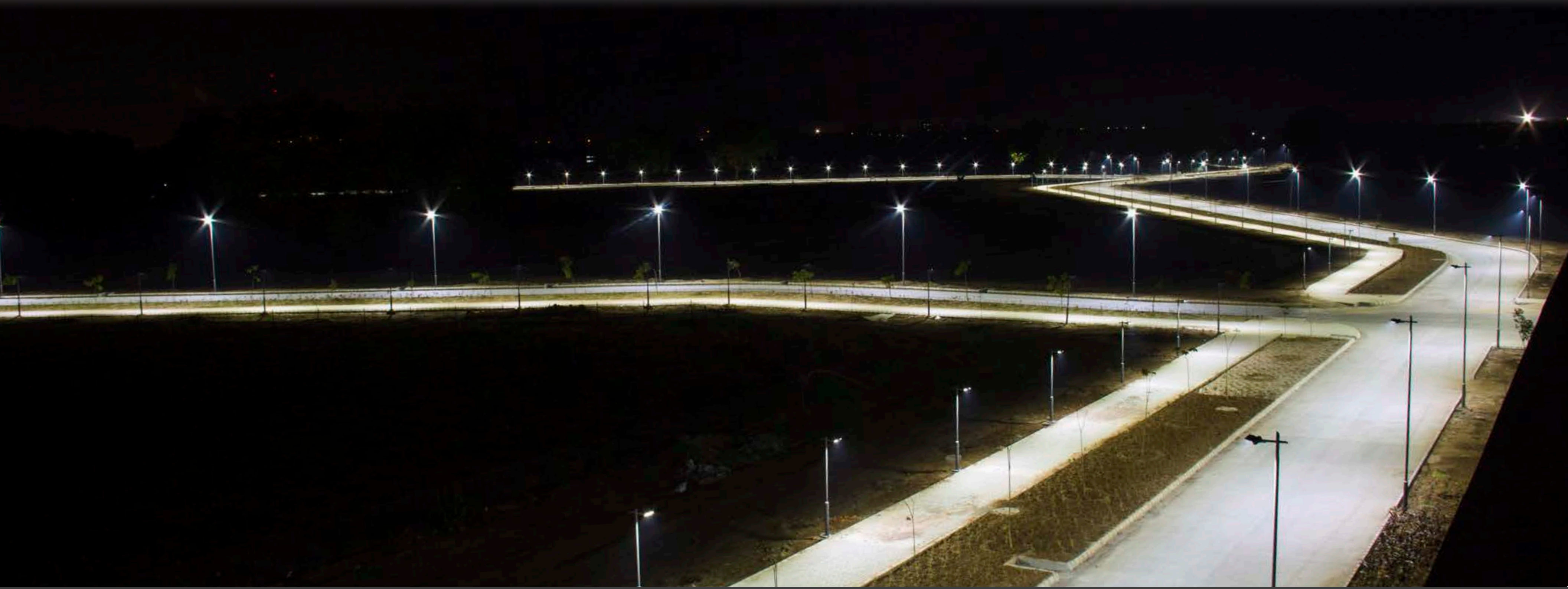
This publication is one in a series describing the development of IIT Gandhinagar's campus on the bank of the Sabarmati River in Gandhinagar. The campus development provided numerous opportunities for innovation and the series is meant to document these.

The focus of this document is on the development of the Masterplan. A consortium of architects from several different firms was selected for this process—Green Campus Development Consortium. This unique arrangement of individuals from several different firms contributed to an active exchange of ideas with participants from the IITGN community. Together all the participants developed the Masterplan that provided the overall vision and structure for the new campus.

Copies can be obtained by writing to the librarian@iitgn.ac.in



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