A brilliantly lit Columbia Asia Hospital, Bangalore

"Patient-friendly Ambience, Functionality, Aesthetics, and Sustainability mark India's top-notch Hospitals."

World-Class Designs In India's Super-Speciality Hospitals

Considering the constant flow of patients from across the world to its super-speciality hospitals, India can be said to have firmly emerged as the Medicare hub of South Asia. High quality specialists and supporting staff, state-of-the-art equipment and facilities, plus patient-friendly ambience in these world-class hospitals have made the country the chosen Medicare destination globally. While quality Medicare per se primarily determines a patient's decision on a hospital, factors like pleasant surroundings, attractive décor, and ease of movement, clean air and overall perception of comfort contribute considerably to the choice. This is where India's super-speciality hospitals appear to be winning.

Indian medical specialists are already an established brand for excellence -- a perception that is complemented today by an equally strong image of the extremely patient-friendly premises of the hospitals they work in. These are the very hospitals that stand out as centres of excellence in concept, design and construction -- a tribute to the country's many specialists in hospital architecture. Their knowledge, experience and skills are comprehensive. They understand the patient's needs, they understand the doctors' requirements, and in their practice, they affirm sustainable development. Utmost eco-friendliness in the designing, use of material, and construction is an accompanying concern with them.

Designing and building a super-speciality hospital is specialised teamwork of professionals from different disciplines --- doctors, medical planners, architects, interior designers, engineers, contractors, operations people, business managers, and others. In such a team, an architect plays the pivotal role

"The most important aspect of designing a hospital is that patients must feel a sense of security and confidence on entering its premises. A good ambience is therefore a must. Large, internally landscaped and spread-out spaces, good lobbies and courtyards, large windows and diffused lights are part of a reassuring ambience for patients."

as he has to understand the needs of every contributor, and weave them together to create the hospital with the patient at the centre. The key parameters to design a super-specialty hospital are functionality-- controlled circulation of people, flexibility and expandability of space-- and aesthetics. Screening and segregation of in- and out- patients, adopting to changing medical needs and treatment modes, defining visitors and logistic routes, providing conducive climate spaces, segregation of waste and supplies etc. are important conditions to fulfil. A comprehensive approach towards all these factors is thus the key to the setting up and working of a well -designed super-specialty hospital.

These hospitals are necessarily designed by ace architects and structural engineers whose mandate is to maintain conditions of utmost comfort to patients, and also meet the exacting requirements of the doctors and other medical staff. The construction methodology of these hospitals takes care of every concern --- technology, sensitivity and safety of patients, and sustainability. An idea of the extraordinary emphasis placed on the comfort level for patients, and the ambience they need, can be had from designers and builders who have specialised in hospital architecture. In what follows, the very people who conceive, design and construct these complex buildings speak on some of the important aspects of such projects from their immense on-the-job experience.

Interiors of Tata Memorial Hospital, Mumbai

Hafeez Contractor, who has designed a number of hospitals in the country including the LH Hiranandani Hospital in Powai, and the Sahara Hospital, Lucknow points out that planning a hospital in a city is very tough as plot sizes are usually very small. So, the top private floors are designed first, and then the public areas. But with larger plots, the public areas can be designed first and the tower can evolve from the design later. He explains that hospitals are designed as sealed boxes to avoid dust, germs and pollution from the outside. The construction materials are carefully chosen, and walls are made thicker than normal at times. There is less ventilation. The planning of mechanical-electrical-plumbing (MEP) system becomes very crucial in a hospital as the functioning of these services is most important in saving lives of patients. This is the nervous system of the hospital and needs careful planning. These hospital buildings are essentially designed to be sterile to prevent contact with the pollution outside. In such hospitals, the architect explains, column-free spaces are designed to enable easy movement of big equipments, as also large numbers of people.

For Rajesh E., Principal Architect, Rajesh Associates who has built multi-speciality hospitals such as the Sagar Hospital, Narayana Hrudayalaya and Indus Westside Hospital in Bangalore, "The most important aspect of designing a hospital is that patients must feel a sense of security and confidence on entering its premises. A good ambience is therefore a must. Large, internally landscaped and spread-out spaces, good lobbies and courtyards, large windows and diffused lights are part of a reassuring ambience for patients."

Satyendar Khurana, Vice President, Projects and Development, Columbia Asia Hospitals Pvt Ltd emphasises that buildings designed for specific healthcare need very careful planning, especially bearing in mind that equipment loads need to be planned right from the beginning and taken into account in the structural design. The other important factors, he says, are the drain points which are large in number and have to be taken into account while selecting appropriate structural systems. "Some of the most important factors that need to be kept in mind are vertical and horizontal zoning of departments based on patient, staff and process flow. Efficient air circulation and ventilation systems, and precision coordination between the services and the systems can contribute much to a patient's comfort and safety," he adds.

Another perspective comes from Peeyush Srivastava,

The most vital aspect of healthcare planning, he says is- "segregating the various departments through horizontal and vertical separations allowing space for everybody including a very efficient logistic system. New technologies like pneumatic chute are creating more efficient healthcare environment." Hospitals today, he adds, "are being designed to provide more and more comfort and care to the patient. Increased awareness about infection control and patient safety, along with use of latest non-invasive technologies are very important emerging trends."

S. Sukumar, the CEO – Projects Division, Indraprastha Apollo Hospitals lists out and explains some of the advanced facilities, and the unique construction aspects as described below, that provide a blend of design, functionality, integration, innovation, style and sustainability in this super-speciality hospital.

Laminar Air Flow-Microbes cause infection inside operating theatres. To overcome this, the Operation Theatre is provided with laminar air flow. This air flow system is supplied through HEPA filters and is capable of filtering all microbes of size 0.3 micron and above. The created laminar flow sweeps all particles within the room and takes them to the filters. This process of air flow and conditioning keeps the OT clean, in addition to providing comfortable environment for its occupants. The Plenum Unit is designed with lighting and diffuser arrangements to suit the specific requirements of the operating team. The ceilings consist of a plenum box supplied with conditioned air from the central system via "S" class filters mounted on the inlet to the supply ceiling. All filters and housings are factory tested and certified to international norms.

The Wall and Ceiling-The walls and ceilings of the modular OT are fabricated out of free standing metal panels. These panels are produced from EGP sheet, S.S.-304 or S.S.-316 grade. All the four wall corners have return air outlets and grill made of powder-coated steel, with colour to suit the hospital interiors. The metal wall panels are mounted on the masonry, or on metal struts. The metal wall panels are finished with anti- bacterial paint. The thickness of the finished surface is not less than 200 microns. Filling of all joints and cavities has been done with metallic epoxy filler, and sanded flush to provide a joint-less finish. They are then sprayed with water-based liquid plastic aseptic and self- sterilising wall coating system to a thickness of 200 micron with primer.

Air and General Lighting- The air and light diffusers consist of two layers of mono-filament precision woven polyester of uniform porosity, with an open area of sufficient resistance to create laminar air flow from the diffuser face. These diffusers are critical in diffusing the air into the theatres uniformly over the total area. The ventilated ceilings are critical in providing

"Hospitals today, are being designed to provide more and more comfort and care to the patient. Increased awareness about infection control and patient safety, along with use of latest non-invasive technologies are very important emerging trends."

Amrita Institute of Medical Science (AIMS) Kochi, Kerala.

Symbolic Representation of the 'Tree of Life' at the entrance of Medanta- The Medicity Hospital, Gurgaon.

> **"Site selection, use of local materials, recycling of water, use of recycled materials, low volatile organic compound in adhesive, reduction in light and air pollution, creating more green and human friendly environment, and safe disposal of medical waste are some of the key ingredients of an eco-friendly hospital."**

the sterility and cleanliness required in the operating theatre. Integral lighting provides an illumination level in excess of 1300-lux.

Sealed sliding doors - Sealed sliding doors maintain desired air pressure in the room. They can be operated manually or automatically with microprocessor-based automation system. The door frame is made out of high quality anodized aluminium extrusion, while the door panel is made of compact laminated board that can withstand high abrasions. The door runs on rubber rollers guided by fixed nylon runner guides. The controller is capable of being operated by elbow or foot switches, or by radar switch. All doors can be easily operated in the event of failure of power supply or of the automation unit.

Vital Sections Design

The 'Tata Clinic and Faculty Block' which is a new 14 storey, 20,000sq.ft building and was built as part of the larger Tata Memorial Hospital, houses specialty clinics, 75 beds, a minor theatre complex, day-care beds, academic offices, post-graduate education units, seminar rooms, and a telemedicine centre.

The block shares the layout of the main Tata Memorial Hospital which is recognised as one of the leading cancer centres in this part of the world. This block has a completely sterile corridor connecting with the OTs in the old building. The ground floor of the new block has the major cancer treatment and equipment room (LA/linac) which was constructed using special concrete. Its walls and ceiling are around 1.7m thick to provide insulation from radiation from the room below. From the outside, the building has a glazed look with a prominent crown made from aluminium louvers. These louvers camouflage the machine room inside. The entrance lobby also has a free standing wall made from steel and clad in granite. It has a glass canopy to add to its beauty. The building has a structural provision for a helipad which may be executed in the future.

According to Peeyush Srivastava, the most important aspect of designing the sensitive areas in a super-specialty hospital, like operation theatres and radiation therapy units, is limiting the secondary infections and the patients' and operators' exposure to radiation. "Operation theatres are moving into a new era of modular-OT with prefabricated standardised panels. Provision is made for laminar flow of air-conditioning, installation of equipment and thereby reducing the time of construction, and ensuring better hygiene control. Strict norms laid down for radiation therapy procedures, and the material used in such spaces demand the utmost care in the designing process," he emphasises.

Discussing planning and design of radiation therapy segments in hospitals, Balaji Rajesh, Structural Design Consultant, Rajesh Associates, explains that the radiation/lenac rooms should have RC walls, RC flooring, and RC ceiling of 1200 mm thickness, and they must be covered with lead sheets. Speaking on this point, Satyendra Khurana of Columbia Hospitals says, "Though radiation therapy is not offered in Columbia Asia hospitals, the rooms for X-Ray, Mammography and CT Scan are designed as per the Atomic Energy Regulatory Board (AERB) norms to ensure that there is no radiation leakage. These rooms are provided with lead-lined doors and lead-lined glass for windows. Besides, the walls are designed to ensure that there is absolutely no radiation leakage."

Rajesh E, opines that, "basically, operation theatres are like workshops which are interconnected. There is a three-way sterile method—the normal sterile, more sterile, and a twist sterile method--where a separate entrance is provided to the patient. There must also be separate entrances for doctors and staff, and they should have their own changing rooms with a 100 percent change of air." He adds further, "Actually a hospital project is a different kind of project altogether. It is integrated with ICUs and a trauma centre, and allows both movements of solid waste and sterile things. As far as the radiology department is concerned, which basically consists of the CT, MRI and Ultrasound facilities, all AERB norms should be strictly followed".

Energy Savings

A study by Better Bricks, a renowned commercial building initiative states that besides annual energy savings of 25% or more in such hospitals, what is more interesting is that with superior infection control like efficient fixtures and irrigation systems, more outside air, filtration etc., saving of water is over 40%. The study notes that these hospitals also provide an enhanced healing and working environment due to natural daylight, high-quality night lighting, good indoor air quality, and access to outside view. An integrated design which blends climate, facility use, loads, and systems, according to the study, plays an important role in ensuring high performance of the facilities.

Discussing the projected energy savings at "Medanta - The Medicity Hospital", a 1250 bed super speciality hospital in Gurgaon, Sanjay Verma, Director, Arcop Associates Private Limited explains, "The more significant efforts towards energy savings in Medanta were towards savings on HVAC (for cooling as well as for heating) because of the insulating properties of Aerated Autoclave Concrete(AAC) block masonry. Use of low-e glass and double-glass units in windows and curtain walls provides good insulation, while argon filling inside the double-glass units enhances the insulating properties of the skin of the building."

Ramesh Khosla, partner-in-charge, Arcop PCJA (a joint venture of four architectural firms from Montreal) and (Arcop Associates Private Limited of New Delhi) stresses that,"Insulation of the roof with extruded polystyrene is by far one of the most effective insulation methodology, while use of heat recovery wheels in the OT AHUs, along with the variable speed drives, significantly reduces the cooling loads on the HVAC system." He also explains that the building uses daylight to the fullest.

Eco-friendly Designs

"The principles of eco-friendly designs are very simple: reduce the carbon footprint while engaging in a complex activity like designing and building a hospital", explains Peeyush Srivastava, adding, "Site selection, use of local materials, recycling of water, use of recycled materials, low volatile organic compound in adhesive, reduction in light and air pollution, creating more green and human friendly environment, and safe disposal of medical waste are some of the key ingredients of an eco-friendly hospital."

In this context Ramesh Khosla explains, "One of the significant eco-friendly

International Patients Perspective:

"Although I have visited India earlier, this is my first visit to Delhi. It feels good to get operated in such good infrastructure. To talk of services, I am fully satisfied with the hospitality of the hospital staff. I find that all the departments and operation theatre are well connected to each other and the attendants and patients are well taken care of," says Ali Saleh Ali, the father of 2 years old Zinav Saleh Ali who was visiting the Fortis Escorts Heart Institute in New Delhi for his daughter's heart surgery. He adds, "There is no comparison in the infrastructure of the hospitals back at Oman and Escorts since there is no healthcare facility available there."

Gomota Lenga Walenga, of Congo says, "The Fortis Flt. Lt. Rajan Dhall Hospital in New Delhi has the best infrastructure in India. I was quite happy and satisfied with its infrastructure. The interconnectivity between different departments is also good."

Ar. Rajesh E.
Principal Architect, Rajesh Associates

The outer facade of the Tata Memorial Hospital, Mumbai.

> **"The planning of mechanical-electrical-plumbing (MEP) system becomes very crucial in a hospital as the functioning of these services is most important in saving lives of patients. This is the nervous system of the hospital and needs careful planning."**

services that is available in Medanta is the availability of treated water from a state-of- the-art sewage treatment plant. This treated water is used for flushing, horticulture, cooling tower make-up etc., thus minimising the need to depend on supply of city water for all these purposes. With this sewage treatment plant in place, Medanta is a "zero discharge" facility with absolutely no connection to the city sewer network."

In this regard, Rajesh E adds, "Our hospitals are designed according to eco-friendly norms. There are sewage treatment plants (STP), solar heaters, recycled water, rain water harvesting, and use of natural materials such as wood, green walls, LEDs etc. besides building and water management systems for maintaining a self- sustaining garden."

Day-light Strategy

Explaining the day-light strategy adopted at Medanta, Khosla says, "To ensure that daylight is harvested beneficially to the maximum extent possible, care has been taken during planning that almost all 'active' areas are along the perimeter of the building so that they get maximum daylight. Unlike most hospitals, even the ICUs, the Pre-op and the Post-op (Recovery Rooms) have been designed to allow natural light to come in. This has been achieved through careful planning of the built form, and by incorporating internal courtyards in strategic locations".

Continuing, Khosla says, "It is common to see hospitals having the toilets attached to the patients' rooms placed along the outside walls of the building so as to save on ventilation and service costs. This arrangement however, blocks off a major part of the outer wall and ends up creating a window for the room at the end of a narrow vestibule along the toilet, thereby considerably reducing the amount of daylight coming into the patient's room. In Medanta, all toilets have been positioned on the inside walls of the patients' rooms, thus allowing the entire external wall to have as big a window as required."

Almost all patients' rooms in Medanta, says Khosla, have large picture windows as big as the external wall itself. According to him, research has shown that a "connect" with daylight and the outdoors helps patients recover faster. "This effort to get as much daylight into the rooms as possible not only reduces electrical consumption for lighting substantially, but also contributes in a big way towards faster recovery of patients."

Structural & Fire Safety Regulation

Describing the structural safety and fire safety aspects during construction of multi-speciality hospitals, Peeyush Srivastava explains, "Disaster management is very critical in a hospital since we are dealing with patients who are not self-dependent. The National Building Code and other structural codes are sufficient to take care of safety measures for structure and fire. The need is to follow the codes strictly and create awareness amongst the service providers."

Rajesh E agrees. "The National Building Code norms for fire safety including detection system like fire alarm system, sprinklers and hydrants have to be strictly followed during construction of any hospital."

Satyendra Khurana informs that "At Columbia Asia Hospitals, all the buildings comply with the fire norms. Smoke detectors, hydrants, public address systems and fire extinguishers are provided on all the floors. Sprinklers are provided in the basement, while fire doors with 2- hour fire ratings are provided in critical areas like the electrical rooms, UPS Rooms, Server Rooms, etc."

Medical Waste Management

Peeyush Srivastava observes that Medical waste disposal is a huge challenge and it is debatable whether or not to have an incineration plant within the campus. "Fortunately," he says, "specialised agencies are coming up to deal with this, thereby making the task more simple and environment-friendly. Water recycling is also an important component of hospital planning. Thankfully, with increased awareness about depleting water tables, it has become more or less mandatory to recycle grey water for flushing and horticulture. Reduction in the availability of land and increased parking requirement has led to a steep decline in greenery around hospitals. But new technologies relating to vertical landscape and terrace landscape are bringing in great possibilities to resolve this problem."

Khosla opines that as hospitals have varied types of waste, each type needs to be dealt with appropriately. He avers that there is a clearly mandated methodology to deal with biomedical waste, and these mandates have been spelt out in great detail in a publication of the Ministry of Environment and Forests, Government of India, called 'Biomedical Waste Management and Handling Rules 1998'. Khosla adds, "In effect, there is absolutely no strategy that needs to be designed by the architects or the hospital. It is a simple case of designing and providing spaces strictly as per the mandates of this document, and then have the hospital operations followed the laid out procedures."

"At the Columbia Asia Hospitals," Satyendra Khurana explains, "we have a very well defined medical waste segregation and collection system. The medical waste is disposed of through specialised agencies authorised to do the job. We also have a separate system for treatment of waste water that is generated in medical areas prior to disposal. A sewage treatment plant is also provided in all hospitals, and the water generated is utilised for landscaping," he adds.

Expertise & costings

Describing the cutting edge technology adopted to reduce the overall cost of construction of a super-speciality hospital, Balaji Rajesh explains, "The shell cost of a building mainly depends upon column grids and beam spans for which reinforced concrete, along with post-tensioned concrete and deck slabs should be used wisely. Also recommended is use of dry walls wherever possible." "Finally," he says, "the architectural design should provide space for balanced structural sections."

Taha Ansari, Director, North Zone, Synergy Property Development Services Pvt. Ltd., a popular Bangalore based Project Management Consultancy Company, that provided design management services and the design and drawing coordination with leading consultants such as PCJA Montreal, Arcop Associates, Spectral Services Consultants, and Technical Projects Consultant for Medanta- the Medicity Hospital says, "Synergy was involved in Contracts Management/ Procurement, right from obtaining Tender drawings and documents, evaluating it and prequalification of vendors till award of contracts. During the Construction Management, Synergy's team of highly qualified and experienced professionals did meticulous planning and monitoring right from the excavation of basement, coordination with multiple Contractors and Vendors of various streams and specialty till close-out and ensured a timely completion within budget with safety and premier quality to the utmost satisfaction of the stake holders."

> **"Multispecialty hospitals are catching up very fast in India particularly in urban India. In the tier 2/3 cities the opportunity for this growth is even better. This is because there is a population capable of affording this kind of care and insurance in health is improving."**
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> **Dr. Nandakumar Jairam,**
> Chairman & Group Medical Director,
> Columbia Asia Hospitals, India.

On the other hand, Ramesh Khosla opines, "More than depending upon cutting edge technology, cost cutting during construction has been achieved through responsible architecture. The effort has been to choose the building material judiciously, and design the building in such a way that what could otherwise have been a very complex construction process gets converted into a simple and streamlined one." In this way, he observes, there would be saving on time and manpower, which eventually translates to savings on construction costs as well as the running costs.

Speaking of Medanta in this context, Ramesh Khosla explains, "The entire building has been worked out on a combination of highly tested grids of 8.5mX8.5m, 8.5mX9.0m and 9.0mX9.0m. These grids allow for extremely efficient hospital spaces (particularly the patient rooms) as well as the most optimised parking spaces. Once standardised, the entire construction was a matter of sheer repetition. This repetition has helped the structural engineer to optimise on the structural costs, and also make physical construction relatively simple, thus saving a lot of time and money." He adds, "Judicious usage of flat slabs, and beam-slab construction in the building too has contributed greatly to savings. While flat slabs tend to be marginally more expensive than the conventional beam-slab construction, its repetition in large areas more than compensated for the additional cost by saving on the time of construction, and allowing us to have much better heights in each floor to accommodate the complex services network that had to go above the false ceiling. Where repetitions were not possible, we adopted the conventional beam-slab construction. Together, the two systems have given the most optimised construction costs that could be achieved."

In addition, says Khosla, "The formwork required for flat slabs is far simpler than that which is required for a beam-slab construction. This saved a lot of time in casting cycle. Further, the wear and tear of formwork for flat slabs is much lesser than for conventional construction."

According to Khosla, the most significant building material that has been used in the construction of Medanta is Aerated Autoclave Concrete (AAC) blocks for masonry which are made out of fly-ash and have very high insulating properties, besides being much lighter in weight than conventional bricks. Use of this material, says Khosla, has made the dead loads much lesser in the building than would have been possible with brick masonry. As a result, he holds, there has been substantial savings in the structural cost. Further, he adds, because these blocks have high insulating properties, the loads on the HVAC system get significantly reduced, both for cooling during summers as well as for heating during winters. In effect, he stresses, AAC blocks have resulted not only in savings on the construction cost, but also on the running costs.

Challenges Encountered

The greatest challenge while designing a super specialty hospital mainly involves the amalgamation of needs of all in a complex environment, yet maintaining the desired standards of operation. "A hospital is a much complex environment than any other architectural space. The need for hygiene standards and technology intervention in a space which revolves around basic human needs makes it far more technical. In a nut shell it's a specialised job to be executed by a specialist," Peeyush says.


Sagar Hospital, Jayanagar, Bangalore

According to Rajesh E, the most challenging aspect of a hospital project vis-à-vis a residential or a commercial project is the renovation work. Most hospitals are done in stages and the entire design has to keep this in mind. "The whole approach has to be totally different. In case of residential projects you are designing for a family, whereas, in case of hospitals you are designing for a patient (as if for a corporate). In the beginning itself, we should plan for expansion because, normally, a hospital keeps growing."

Any renovation work in a hospital is difficult according to Rajesh E. "The most challenging part faced by us while constructing the Sagar Hospital was connecting an old block to a new block--integrating the two was challenging work. The other challenge that we faced was in construction of the Indus Westside Hospital which required construction in front of a lake. Despite this challenge, we went for double basement, which we are not used to under such severe soil conditions in Bangalore."

While Taha Ansari adds, "The construction of Medanta started in early 2006 and after testing and commissioning of the building, all the major operations of the facility were made open for public in November 2009. Spread on 43 acres of land with a built-up area of 2.3 million square feet, providing 1250 In-patient beds with 350 Critical Care beds, 42 State-of-the-Art Operation Theaters, 5 Cath Labs, Medanta - The Medicity truly was a mammoth project in all sense of the world. Constructing the gigantic structure and starting the hospital operations in less than 4 years is an achievement of its own kind."

Going Green

The seventh hospital of the Fortis Hospitals Group spread over 7.5 acres in Shalimar Bagh, north Delhi has been designed according to the parameters laid down by the Bureau of Energy Efficiency, Government of India, as an energy-efficient building that complies with the Energy Conservation Building Code. The hospital building is the first to receive the "TERI GRIHA" Green building rating from the TERI (The Energy Research Institute).

Daljit Singh, President, Fortis Healthcare (India) Limited says, "The principles of sustainable development encourage the use of technologies which consume industrial waste (like fly ash), and less energy in the production of materials required for the construction of this 550 bed tertiary care hospital. The technologies deployed reduce the energy consumption when the building is in operation, thus reducing the building's carbon footprint. There is emphasis on minimising the demand for non-renewable resources and maximising the utilisation efficiency of these resources when in use."

He further explains, "The features incorporated in the building towards reducing the energy consumption include a computerised simulation software which optimises the heating and cooling of the building, appropriate orientation of the building to minimise solar heat gain, deploying of high efficiency (low energy consuming) machines for air-conditioning, use of high efficiency glass on the external face of the building to reduce the energy demand, solar films positioned on glass to reduce energy intake, use of variable speed motors to reduce energy consumption in the air-conditioning system, bringing down lighting load by use of high efficiency CFL fixtures, daylight integration in common areas to conserve power, and insulation of the roof to reduce ingress of heat."

"The Renewable Energy systems installed in the hospital include a Solar Water heating system which can meet approx 86% of the hospital's hot water demand, and solar electric lights which contribute up to 33% of the external lighting," he says.

Material Efficiency he adds has been achieved with the use of low VOC Paints used on the building exteriors, use of

> "The principles of sustainable development encourage the use of technologies which consume industrial waste (like fly ash), and less energy in the production of materials required for the construction of this 550 bed tertiary care hospital."

Fortis Hospital - Shalimar Bagh, North Delhi

composite wood to reduce use of regular wood, cement with high fly-ash content to reduce consumption of regular cement, use of hollow cement/fly-ash bricks to minimise both heat gain and cement consumption, and environment-friendly CFC-free insulations and refrigerants.

He explains that this patient-centric philosophy of the hospital finds expression in every aspect of its design. The design ensures patient-friendly processes, makes for generous bed-to-floor space ratios, well-lit patient and attendant areas, with special attention being paid to maximise natural lighting. In addition, there is a beautifully landscaped garden designed to have a calming effect on all users. Special care has been taken to provide contemporary hospital furniture for patients' convenience, both in acute and non- acute care areas. Patient rooms are comfortable and cheerful, and cater to most of the functional requirements of patients and attendants. High end rooms and suites provide privacy and comfort designed to cheer the patient and, thereby, help in the healing process.

These views of leading architects and builders not only emphasise the tremendous progress Medicare infrastructure has made in India, but also shows that there is immense potential for further growth. In its publication, The Indian Healthcare, KPMG, a tax and advisory services and industry Insight Company, states that the health infrastructure across India is projected to grow by an average of 5.8 percent per annum between 2009- 2013, taking the total projected expenditure to USD 14.2 billion. Out of the 32 states in India that have been considered by the report, the six states of Maharashtra, Rajasthan, West Bengal, Uttar Pradesh, Tamil Nadu and Andhra Pradesh alone are forecast to represent approx 50 percent of the expenditure for 2009-2013 period. Besides, it states that the healthcare sector in India is undergoing a phase of reform propelled by rapid economic growth. Apart from healthcare providers, the report points out those newer enterprises such as diagnostic chains and medical device manufacturers are also attracting increasing amounts of investment. At this pace, it may not be long before India's Medicare infrastructure may well grow to become a larger provider of healthcare support to a major portion of the global population.

Caroline Andrade and Renuka Vembu contributed to this article.

Corridor of Fortis Hospital - Shalimar Bagh, North Delhi

Front Elevation of Medanta- The Medicity, Gurgaon.

The Making of Medanta- The Medicity

Ramesh Khosla, Partner-in-charge, Arcop PCJA– a joint venture of four architectural firms from Montreal – and Arcop Associates Private Limited – the architects on record from Delhi – speak to BE's **Caroline Andrade** on the concept, design and building of Medanta - the Medicity of Gurgaon, Haryana, India.

What kind of medical intelligentsia has been associated with this project, and what is the state-of-the-art infrastructure adopted in it?

The "medical intelligentsia" and the "state-of-the-art infrastructure" are incorporated in Medanta more in terms of a team of some of the best doctors led by Dr. NareshTrehan himself, and best medical equipment that we can ever get in this part of the world. The building has been designed to respond to the requirements of such doctors and equipment, and their related workflows. The best way to understand this is by looking at a few examples.

The imaging and diagnostics have some of the most advanced equipment for MRI, CT Scan etc. Their electrical and climate control requirements are fairly stringent. The positioning of these equipments, the electric supply, the humidity and temperature control of the spaces – all had to be designed withabsolute precision.

The linear accelerators (equipment used for radiotherapy as a treatment for cancer of many kinds) emit very high frequency photo neutrons that kill cancer cells. However, by virtue of what they are, they are equally capable of killing healthy human cells too. Quite predictably, it is mandatory to house these equipments in highly shielded spaces such that they will not allow any of the radiations to find their way out and harm people outside. These spaces have been created out of 1.2 – 1.5m thick concrete walls which become 2.5m thick in the zones of highest radiation.

Nuclear medicine is used for treatment of certain diseases. The challenge here is to deal with the highly radioactive medicines, isolate the patients from others, and disposeoff the effluent safely. This is one place where "flows" have been managed with surgical precision to ensure that all the issues are taken care of. The spaces have been shielded with lead lining.The patients stay in isolation spaces where they are attended to by doctors, nurses and paramedics wearing protective suits. The radioactive effluent is drained into a holding tank until they "decay" or lose their radioactive properties over multiple half-life cycles before being disposed off via the effluent treatment plant into the sewage treatment plant.

To respond to the highest standards of health care, this hospital has been designed for the very best in infection control. The entire hospital has spaces that are under varying degrees of air pressure. Some spaces have been designed to be under high pressure to ensure that nothing airborne can enter such spaces, while some spaces are designed to be under low pressure so that nothing airborne can go out of such spaces. The HVAC systems have been exacted to respond to these requirements in all such spaces. And these systems in turn, have been backed-up by precision engineered doors, windows and other openings to ensure complete sealing off of all their edges when closed.

Movement systems play a major role in controlling or propagating infection. The hospital has been planned to provide very clear and distinct paths for movement of patients, staff, visitors, material, food, garbage and so on. At no point of time can the garbage and the patient find themselves next to each other in a corridor or in an elevator. Talking of material movement, Medanta is one of the first hospitals in India to incorporate a 48-stationed pneumatic tube system for the movement of samples from any part of the hospital to the clinical labs. This reduces human handling (and hence, contamination of any kind) and saves on time, thereby bringing in better efficiency into the overall system. Medanta is full of such examples, and we could go on and on describing all of them.

Describe the unique construction aspects of the operation theatres, in the hospital?

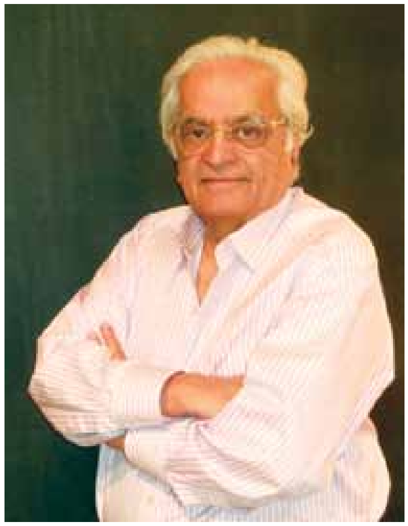
The OTs are essentially modular construction made of steel panels that are tongue and groove jointed into each other with poly-urethane foam injected between them. The components are precision assembled to exacting standards. There is no masonry wall to create the OTs. The finishes are absolutely jointless so as to ensure that there are no cracks and crevices where dust and dirt can collect. Conventionally, we are used to seeing a sharp right angle between the walls and the floor, and the walls and the ceiling. These sharp joints gather a lot of dust. To avoid this, all such joints have a curve and the finishing material simply wraps up along these curves. This makes cleaning of the OTs much easier and effective.

HVAC plays a crucial role in making a successful OT. All the OTs are designed to the best standards of laminar airflow where the conditioned air is gently dropped down from the ceiling, and the return air is picked up from the bottom of the walls. With the right kind of hepa filters and precision control of temperature, pressure and humidity, infection control is achieved to the maximum. Each OT has a dedicated double-skinned AHU which works on 100% fresh air backed up with heat recovery wheels. This simply means that every bit of air that the AHU is sending down to the OT is processed out of fresh air, and not from air recycled from the OT or any other hospital space. Further, each OT has a dedicated AHU which ensures absolutely zero mixing of air between different OTs. This is another major in infection control which not many hospitals manage to achieve, because of the relatively much higher capex and running costs.

The orthopedic OTs are designed to have temperatures as low as 16^{o}C. The latest technology of bone jointing uses cement that sets at 20^{o}C. It is malleable only at temperatures that are 16^{o}Cor less. To have the orthopedic OTs functioning successfully, the temperature and humidity have been precision-controlled to be within working limits.

One of the OTs is a highly advanced facility with capability of Intra-Operative MR imaging and MR guided surgery. In this OT (which is commonly called the Brain Suite), the surgeon can perform a high resolution MRI during the surgery to assess the exact nature and extent of a tumour and remove it without interfering with the normal brain tissues. The safety of such surgeries is enhanced by special techniques to visualise the tumour during surgeries. This technique is called Tumor Luminescence. To make this OT work, the space had to be designed to an extremely high degree of precision in terms of electrical, HVAC and space definition. Even structurally, this OT had to be designed from basement all the way up to the 1st floor (where this OT is positioned) in order to take the heavy loads involved in the MRI equipment that got installed here.

Many OTs are equipped to perform minimal invasive surgeries using robotics. The equipment involved in these OTs too are highly demanding on the back-end services.



Ar. Ramesh Khosla,
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Ar. Sanjay Verma,
Director, Arcop Associates Private Limited

Is there any LEED Certification given to Medanta?

There has been no effort towards acquiring a LEED Certification. However, because of the sheer responsible architecture, this building is likely to be in a position to achieve a LEED Gold rating if put through an assessment. ■