

STERLING

ENGINEERING CONSULTANCY SERVICES PRIVATE LIMITED

Quarterly Newsletter | July 2010 | Issue: 2

Special Feature:

❑ Residence Antilia

❑ Research & Development

❑ Past, Current and
Upcoming projects

Residence Antilia

Introduction:

Located at Altamount Road, just off Peddar Road in South Mumbai, Residence Antilia is an extraordinary high rise building, constructed as a private residence for Mr. Mukesh Ambani, Chairman of Reliance Industries and his family.

This structure rises 160 meters above ground level and has two basements. The general floor plan dimensions are about 47 meters x 43 meters. The total built up area is about 42,000 sq. meters. Since the residential floors begin above 109 meter level, they enjoy panoramic views of the city in all directions.

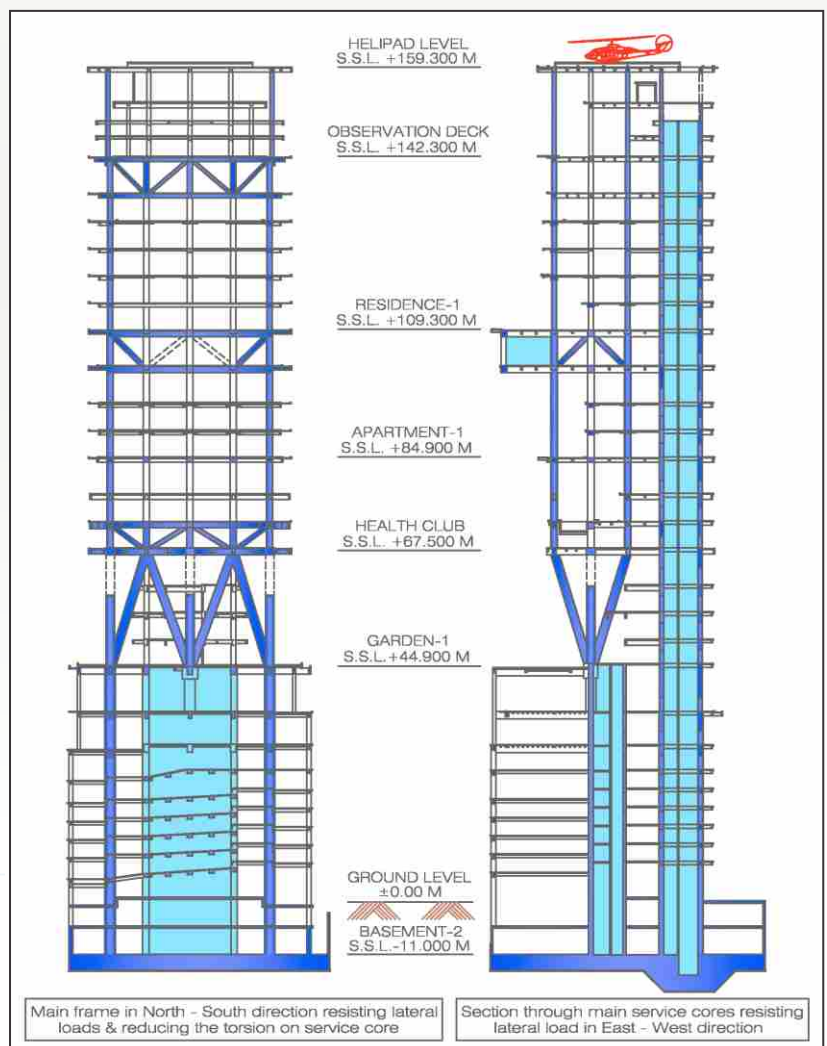
The original structure was conceived as a structural steel-framed building and was designed by M/s. Arup from their UK office. However, the structural steel members required as per design were very heavy and almost impossible to fabricate, transport through the city to the site and to erect in position - even with the best available resources. Besides, joining the fabricated pieces by carrying out butt welding at site was seen as impractical and unreliable. Hence after careful review, it was decided to convert the design into an RCC framed structure. Sterling then shouldered the responsibility of producing the revised structural design. Perkins & Wills - the Architects from Chicago, USA - were pleased to see that their original architectural intent was kept intact even after the conversion. There was no significant increase in sizes of the structural members.

Planning:

The grand entrance canopy on the eastern side provides a clear headroom of 5.2 meters with an impressive overhang of 11 meters. The canopy is covered with glass to permit natural light. The entrance leads to the Grand Ballroom located at the upper basement level. The magnificent Ballroom is 44 meters long and 13.5 meters wide. The lower basement has water tanks, pump rooms, telecommunication room, electric sub-station, etc. Above the ballroom level, there are six parking floors over which there is an entire mechanical floor. This is followed by an entertainment floor with a plush home theater. The main garden level is planned at 45 meters. Twenty two meters above this level is a service floor followed by two Health Club floors with a swimming pool and associated facilities. Next, there are two guest floors with apartments for resident guests. Finally, the four residence floors rise above 109 meters level for the exclusive use of the Ambani family. Above this is a mechanical floor with a void in between to isolate noise and vibrations from the upper floors. Above this floor is an observatory floor and library at 141 meters. Finally, there is a helipad at 159 meters level. In all, there are three refuge floors and three mechanical plant floors at different levels in the building. A service core comprising of nine elevators, two stairs and service shafts is located on the eastern face of the building. Some of the external walls have been designed as vertical hanging gardens.

Structural Scheme:

Very hard rock stratum was encountered at the lower basement level. The building has a 3 meter thick RCC raft foundation designed by M/s. Arup. In order to provide column free space for the ball room, directly under the tower block, the main columns were pushed back towards the core. This also enabled the architects to achieve column free car parking floors above the banquet hall. The banquet hall has a clear height of 10.5 meters and the ceiling has been fitted with specially imported chandeliers weighing about 25 tonnes, these are suspended from a steel platform - which in turn is suspended from the first parking floor.



As a structural scheme, the elevator and stair cores form the main spine of the building. However, the service core is eccentrically placed. The remaining areas are supported on suitable column grids which are about 7 meters x 5 meters. For the purpose of the structural analysis, a space frame model was prepared using STAAD-Pro software. Apart from conventional gravity loading, special attention was given to seismic parameters. Although Mumbai is located in Zone III as per current IS Codes, the owners decided to adopt the parameters of Zone IV as an abundant precaution. Similarly, considering the unusual structural irregularities in this building, the response reduction factor “R” was taken as 3 to obtain conservative results. This factor was further reduced to 2 after deliberations because it was found to be better to rely on strength than on ductility.

Wind tunnel tests were conducted by BMT Fluid Mechanics Limited at London, UK. The tests were used to assess both the design wind loads and the acceleration arising from wind induced motions. According to International standards, the recommended limit for acceleration at the top of tall buildings is about 15 milli – g under the most severe wind condition. However, based on the clients' specific desire, the acceleration was further reduced to 8 – 10 milli – g by increasing the stiffness of the structure.

Construction challenges:

When the structural design was revised from steel to concrete, most of the columns had to be heavily reinforced in order to retain the original cross-section. The stress levels in these columns were significantly higher compared to those in the thick shear walls of the service core. The computer analysis revealed the non-uniform elastic deformation of these load bearing elements and indicated significant tilt of the structure towards the west under dead-load condition. The service core was therefore, constructed with a carefully calculated “tilt” towards the east so that, under fully loaded condition, it would come back to a nearly vertical position.

Above the main garden at 44 meters level, each “mega column” was split into 4 tapering circular columns forming an inverted pyramid. The free-standing height of these tilted columns is 22 meters. The construction of these 1600 mm diameter columns posed a challenge. Two piece, semi circular steel forms were specially fabricated for each and every column. These forms were rigidly supported on well designed staging and the entire staging was kept in position till the upper floor tying all these inclined columns was cast and cured.

The second mechanical plant floor at 101 meters level, as well as the first residential floor at 108 meters level, is cantilevered by about 9 meters beyond the front row of columns. Therefore, a special well braced staging of about 56 meter height was erected to support the formwork exclusively for these cantilevered floors. This formwork was kept in position for over two months while the superstructure construction advanced.

There are two extraordinary helical stairs within the residence for internal communication. Since the designs for these stairs were not finalized at the time of construction of the residence floors, suitable cutouts were provided in the floor slabs. Subsequently, elaborate fabricated structural steel stairs were erected and anchored into the RCC floors.

The challenging design of RESIDENCE ANTILIA stretches the boundaries of architecture and engineering. With its high level of complexity and innovation, it is an excellent example of modern day revolutionary skyscraper design.



Residence Antilia: Current Stage

❖ Sterling Team at Residence Antilia:



S. B. Malekar



Vishwas Date



Sanjay Shirke



Mohammed Mulla



C. L. Lad



Rahul Thakur



Chandrashekhar Tambe



Anand Raut

Some Of The Interesting Projects Under Construction

Waterfront Tower - Colaba, Mumbai

Waterfront Tower is a high rise residential building in Colaba, South Mumbai. The building comprises of a single basement, eight parking floors, two stilt floors, twenty five residential floors and five refuge floors at various levels. The plan dimensions are 18 meters x 28 meters and the height of the tower is 157 meters above ground level. Due to such slim proportions of the building various checks were carried out for the stability of the structure against overturning.

The eight parking floors house three solid cores – comprising of the Staircase core, Puzzle Parking core and the car parking core. These parking floors are supported on suitable column grids and post tensioned slabs interconnected by the RCC floor beams. Above the parking level is the transfer girder level. Two of the three cores stop at this level. 3.8 meter deep transfer girders are provided at +38.73 meters level to transfer the column loads of the upper 30 floors to the solid cores below. The staircase core extends all the way up to the terrace level.

The residential floors are designed using conventional column, beam and solid slab system. The maximum lateral deflection of the building was found to be 300mm which is within limits specified in IS codes. However lateral bracings are introduced along the shorter direction of the building at every refuge floor to reduce the deflections even further.



Essar House - Lonavla, Mumbai



This is a lavish 30,000 sq. feet holiday home to be built at Lonavla. Situated on a steep slope, the building has an architecture resembling an African Jungle house. However, being a luxury house, the intentional wilderness is furnished with modern comforts and interior aesthetics calling for intricate structural systems. The basic framework is in concrete, but interestingly, the contractor has been asked to leave the forms unfinished and all structural elements are required to be irregularly curved, out of level by design and intentionally rough. The architects on the other hand, are more particular about the finishes and textures. This, however, brings in many challenges in imagining the actions of the structural members and designing for the intended eccentricities.

Satellite Tower - Breach Candy, Mumbai

The building is a very luxurious stack of duplexes with individual gardens along the entire periphery of the duplex. There are 16 duplex apartments in the tower with a provision for 9 additional duplex floors. Each duplex floor has a height of 7.5 meters. The first duplex level starts at +30.0 meters above the road level to enable all the residents to get a wonderful view of the vast Arabian Sea.

There is a grand entrance lobby with a height of 18.5 meters. The lobby level leads to the club facility along with the open terrace garden and a party lounge. A separate four storied structure houses the car parking requirements and is accessible by ramps. On the roof of the parking structure is a swimming pool and gymnasium for the residents of the building. This level is also accessible from the lobby level.

The cylindrical form of the building is quite helpful in mitigating the wind effects. Service floors with outrigger trusses have also been provided after every 8 duplex floors to reduce the lateral sway of the building.



Recently Completed Projects

Planet Godrej - Byculla, Mumbai



As you approach south Mumbai on any of the main arterial roads, a fabulous wall like building looms large on the skyline. This 48 storey wonder is a marvelous structural engineering feat which can be seen through its slender form and its gentle curvature which lends it the stability it requires against wind and earthquake. This "wall" is composed of a series of 5 high end residential buildings which are 28 meters x

11 meters each in plan. The typical floor to floor height is 3.2 meters. The complex has a podium with club house, high speed lifts and common amenities. Concrete grades used in this building were M: 60, 50 and 40. The total height of the tower is 168.5 meters.

Grandeur - Kandivli, Mumbai



This 33 storey building towers high and stands out in a cluster of residential buildings on the Western Express Highway at Kandivli. With its glass and aluminium cladding and sharp RCC blade walls all the way from bottom to top its height is further accentuated. Mivan formwork was used throughout the building to ensure rapid progress and a good quality in the finished concrete surface. The design involved concrete grades of M: 60, 50 and 40. The foundation is a raft embedded 9 meters below ground where a reasonably good

stratum was found. Piling could not be adopted due to the presence of boulders in the otherwise loose soil. Due to very high stiffness of the building, the deflection at terrace level in wind conditions is expected to be less than height/1000.

Tata Cancer Research Centre and Hospital - Mumbai

Tata Cancer Hospital is known throughout the country for its contribution to cancer research and treatment of cancer affected patients. Sterling was proud to be appointed as the designers for its new state of the art hospital and research building at Lower Parel, Mumbai. The architecture of the building is befitting the modern hospital functioning and comforting to the senses. The highlights of the structure include the 3.5m deep transfer girders which facilitate column free public areas, consulting rooms, waiting areas and operation theaters at lower levels under a stack of 12 storeys of patients wards with self contained rooms. The structure has an enormous atrium with shell shaped structural steel roof covered with aluminium sheets and glass panels. A tubular futuristic bridge connects the old hospital to the new operation theatres which float through the atrium on three free standing circular steel columns.



Oberoi International School - Goregaon, Mumbai

This modern school building sets a trend for future schools. The structural system used is RC flat slabs with a regular column grid. However, with intricate pattern of openings in the slabs and landscaping at all levels, the design was quite complex. There is an Olympic size swimming pool at the fifth floor level, badminton and squash courts at seventh floor level. The top floor is designed to accommodate libraries, auditoria, jogging tracks and tennis courts making the design and detailing quite tedious. However, the end result is a spacious and enviable school building, where even the design engineers would love to go back to school if it was possible to take some years off their age!

Vivarea Towers - Mahalaxmi, Mumbai

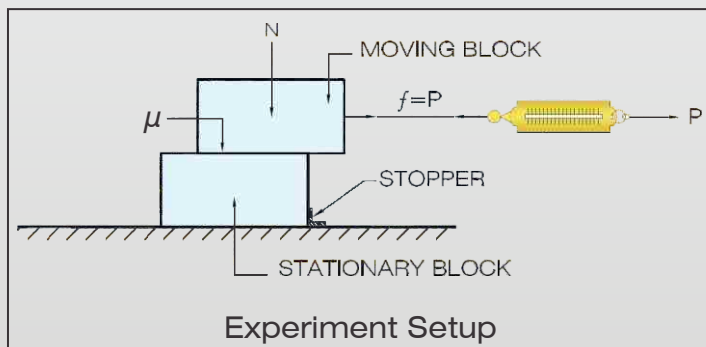
These three residential towers stand 172 meters tall where the Hindoostan Mills once stood at Jacob Circle. The complex has all the amenities for luxury apartments as well as duplex flats at upper levels. There are two stilt levels above which there is one podium level with car parking and club house. The 41 residential floors rise above the podium level. The floor to floor height is 3.8 meters and each floor is planned for three apartments. Due to the repetitive nature of the layout, Mivan Shuttering was used for the three identical towers and this minimized errors in shuttering, eliminated the need for internal and external plastering and ensured speed of construction. The buildings rest on a 2.5 meters thick raft foundation laid on braccia rock. This high rise structure was proof checked by Ove Arup and Associates from their Hong Kong office and the wind tunnel tests were carried out by RWDI.



Research & Development at Sterling:

Vertical Post Tensioning

This time, once again we are going to talk about a minor aspect regarding the transfer girders of Palais Royale. It can be imagined that concreting these 9 m deep girders in one operation was impossible. There were bound to be construction joints in the girders. Our detailing team had cleverly avoided any vertical construction joint throughout the complete length of the girders. However, horizontal construction joints had to be provided and the girders had to be cast in self leveling layers, limiting the maximum pour quantities of about 1000 cu.m at a time. In the 9 m depth of the girders, five layers with four horizontal cold joints were expected. In order to make these five different layers act together as one single monolithic section, it was necessary to bind the layers strongly and develop adequate horizontal shear stress along the cold joints, so that the surfaces of the individual layers in contact did not slide against each other. It was decided to achieve this by developing frictional forces along the contact surfaces. This was the origin of the idea of introducing vertical post-tensioning as a design requirement.



Friction is defined as “the force distribution at a surface of contact between two bodies that prevents or impedes any possible sliding motion between two bodies.” The second law of friction postulated by Coulomb states that “the total frictional force that can be developed is proportional to the normal force transmitted across the surface of the contact.” In the case of the layered transfer girders, the relative translation between the layers had to be avoided. Thus, it was necessary to produce a normal force perpendicular to the plane of contact. This normal force was produced with the help of the vertical post-tensioned cables.

Coulomb's second law can be expressed mathematically as :

$$f \propto N, \text{ Hence, } f = \mu \cdot N$$

where f is the total frictional force, N is the normal force and μ is the coefficient of friction corresponding to the surface and material characteristic of the two layers.

Knowing the value of the frictional force to be developed, it is possible to calculate N , the pre-compression that needed to be applied across the five layers of the girder. The unknown that remained was the coefficient of friction, μ . Although various references and text books provide value of μ , there is a vast variation in all these values. Also, the design team was conscious of the fact that the material being used in the girders was M:60, self compacting concrete, for which little or no research would have been carried out to ascertain its μ value. This led to a very preliminary research experiment in the office and at the site to determine μ value of the M:60 SCC being used in the construction of the girders.

Versatile and enthusiastic Sandip Ghadigaonkar in the administration was entrusted to assemble a set up for the experiment to determine μ . After understanding the experiment from Ravi, Sandip decided to collect a spring balance, inflexible strings, pulley and a stand. The objects under the experiment were blocks of concrete cast with the same material as that used in the girders with different surface textures. The blocks were kept one over another. The lower block was secured so that it remained firmly attached to the table top. The string was attached to the upper block of known weight. It was also possible to increase the normal force by placing some weights of known denomination over the top moving block. The force was measured directly with the help of a spring balance. The spring balance was pulled until the block just began to slide over the lower block. The reading of the spring was the force required to move the block from its position of rest. In short, that was the impeding or maximum frictional force between the two surfaces. The experiment was repeated a number of times at site in the concrete laboratory with the active involvement of our site engineer at Palais Royale, Sameer Pednekar. The ratio of the frictional force to the normal force gave the value of μ .

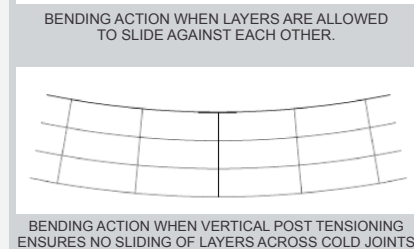
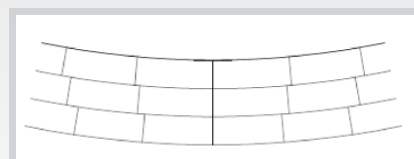
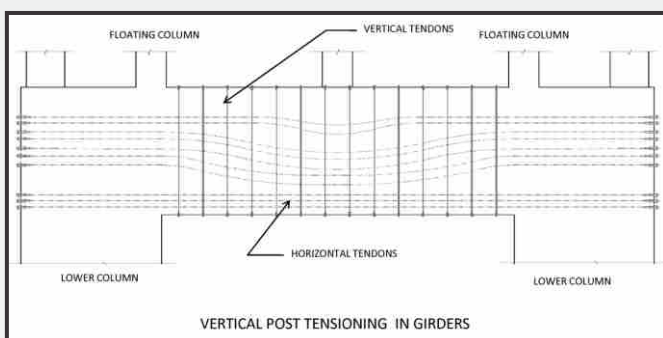


Sandip Ghadigaonkar



Sameer Pednekar

The stresses in various post-tensioned cables have been calculated with this value of μ . With the hands on experiment, the design team is confident of the monolithic action of the girders.



Did You Know?

- In the March issue of our newsletter, we had mentioned that there are at least 5 members whose fathers have also been at Sterling! These names are:

F Mr. N.B. Hadker	- S Mr. Kamal Hadker
F Mr. Kamal Hadker	- D Dr. Deepali Hadker
F Mr. K.B. Patil	- S Mr. Amol Patil
F Mr. Vaman Thakur	- S Mr. Rahul Thakur
F Mr. Vasant Bhogale	- S Mr. Vinayak Bhogale

F: Father D: Daughter S: Son

Taking a cue from the above family dedication to the company, Ashok Patil informs us that the Parab brothers have all been in our Administration section for over twenty years! They are Harish, Bhalchandra and Ganpat!

- Mr. Kamal Hadker and Mr. Sam Malekar both went to the same Engineering College - VJTI and graduated in the 1963 batch. That makes it nearly 50 years of friendship!
- So also, Mr. Pramod Sahasrabudhe, Mr. V. L. Naik and Mr. Girish Dravid were classmates for their graduate and post-graduate studies at IIT Bombay in 1981 and 1983 batches respectively. They have been together for the last 34 years. (Are there any more friendships like these flourishing in Sterling environment?)
- One of the early high-rise residential tower in Dubai is the well known Deira Tower. This was designed by Sterling, with personal involvement of Mr. Kamal Hadker in 1976. It drew attention because of its slip formed service core and flat slabs cast around it subsequently.

Recent Events:

- We congratulate Arvind Kalsulkar from our accounts department as he was blessed with a baby girl. Our heartiest congratulations to Ravi Surlekar, Shraddha Dhavle, Pandurang Ghonge and Archana Parab who were all blessed with baby boys each!
- On Akshay Tritiya Day, Dynaneshwar Pendurkar tied the knot and on the 24th of May, Vaibhav Bhagat too got married. We wish them a happy married life!

- Girish Dravid was in London in the second week of April in connection with the co-ordination meetings for the Chepauk Stadium Phase II. (Many of you may have watched the IPL matches with three stands of the Chepauk Stadium with tensile structured roofs, which Ravi Shastri praised over and over again during his commentary). On the very day of his scheduled return to Mumbai, the volcano Eyjafjallajokull erupted in Iceland, closing all European airports due to flying ash - notably different from the famous fly ash used in concrete, just to keep the records straight. He was stranded in London, worrying about the office and home (so he says), making many extremely jealous of him. He finally got on the very first flight that left Heathrow airport for Mumbai after six days. But say, what a fortunate world class historic geothermal event that allows someone to be stranded in a dream city!

(Record in your own voice, the pronunciation of Eyjafjallajokull, and send the sound clip via email to vindadravid@gmail.com. The correct pronunciation will get acknowledgement in the next issue and a recommendation to the management to send the winner on a trip to explore Eyjafjallajokull volcano on foot!)

Down Memory Lane (This feature revives memories of old and remarkable projects)

Bombay Stock Exchange

The construction of this tower began in the early 70s under the Chairmanship of Mr. Jeejeebhoy and was completed in phases in the late 80s. Located at the intersection of Hamam Street and Apollo Street, in Fort, Mumbai, the Bombay Stock Exchange is the oldest stock exchange in Asia! The biggest challenge was to ensure that functioning of the stock market continued without any interruption during construction. The unique feature of this modern 28 storey tower block is its central service core which houses eight elevators, two staircases, toilets and air handling units. This was the first service core in India, of this height, which was constructed using "slip forming" technique. The entire core above the podium level was slip formed in less than 3 weeks. The core rose at the rate of one floor per day!

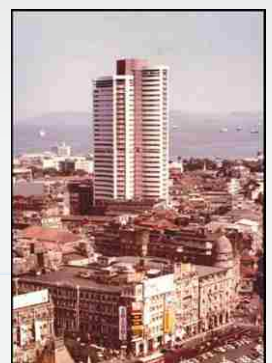
The surrounding floor plates were cast subsequently. The entire floor plate is supported on peripheral load bearing steel mullions. For the first time in India, steel blooms were designed to function as load bearing columns. The additional cost incurred was justified by the increase in the carpet area available on all floors. The size of these steel blooms ranged from 9" x 9" to 7" x 7" in cross section thus allowing maximum clear views of the surrounding cityscape.

This iconic building was targeted in the 1993 bomb blasts in Mumbai. A bomb was placed directly below the main trading hall at the upper basement level. It caused extensive damage to the upper basement and ground floor slabs. However, the important Trading floor and its roof supporting the entire rotunda structure above remained intact.

Incidentally, the Bombay Stock Exchange outshines the Taj Mahal as being the most televised Indian building!



The slip-formed core



BSE: Present Day

Editorial



Our Inaugural issue turned out to be quite a success and was well received by our staff and associates as they saw the wide range of projects being handled in the company. Putting this issue together was an even more exciting experience as we were flooded with valuable material on recently completed projects as well as projects under construction. I thank all of you who have made these contributions to our newsletter.

This issue clearly highlights two things – the complexity of projects we have in hand and the pioneering efforts of our engineers in finding solutions to these demands and pushing the boundaries of engineering possible in our country!

Projects like Residence Antilia, Satellite Tower, D. B. Mall and Waterfront Tower all demonstrate that Clients are developing more and more trust in our abilities as Sterling successfully handles such complex designs. On one hand it is believed that engineering and architecture are like two sister professions separated by a morass of mutual misunderstanding! Yet, at Sterling we can proudly say that the architect's creative perception is translated into structural logic. Many of the leading architects we work with often compliment us for our understanding of aesthetics in architecture.

It is this feeling of accomplishment and success that has led to even better designs and structural solutions as our engineers work with composite construction, use of advanced techniques and continuous research to bring the company to the forefront of structural engineering in India.

Dr. Deepali Hadker

Focal Point



Here we are, once again with another newsletter. This edition includes the previously seen sections of the recent and on-going projects, which comprise of some of my personal favourites like Planet Godrej and Oberoi international School. One of the most talked-about buildings of Mumbai- Residence Antilia has been discussed in detail as the main feature. We also have introduced the new "Creative Strokes" corner

where the artistic expressions of Sterling members will find a place. We feel it is vital to encourage such talent along with focusing on core abilities. I call upon all our engineers and draftsmen to contribute to this section.

It was truly delightful to receive contributions from S. B. Malekar, Manish Negandhi, H. M. Jha, Ketan Chaudhary, Amit Shinde, Abdul Hafeez, Chandrashekhar Pawar and Ashok Sawant and I hope this induces more people to participate in the making of the newsletter.

It was also heartening to receive an unexpected appreciative letter from Mr. David Skinner of Leighton, which I have shared below with all of you.

We hope this issue is even more informative and enjoyable than the previous one. Keep sending in your contributions and responses to vindadavid@gmail.com

Vinda David (Assistant Editor)

Reader's Response (Received via e-mail)

Dear Ms Dravid

I picked up a copy of Issue 1 of your quarterly newsletter last week during a visit to Sterling's BKC office. I am impressed by the breadth of work that Sterling have underway, (they are the structural consultant with us on the TRIL Chennai project) and also the innovative ideas being used, some possibly for the first time in India. I particularly liked the construction methodology used on the Palais Royale.

Do you have a mailing list, as I would appreciate a copy of your future issues and if not being done already, it would be very sustainable to produce a pdf version that could be e-mailed to interested parties.

Thanks and Best Regards

David Skinner

Building Operations Director, Leighton Contractors (India) Pvt. Ltd.

Creative Strokes



These are the sketches of famous actors drawn by Ameya (Std. VI) who is the son of Ashok Deshmukh from BKC office. It is truly delightful to see such good talent and it is absolutely necessary to encourage such skills. If

any of you have a flair for paintings, sketches, art, poetry or any other talent please do share it with us.

Recent Welcomes

We welcome

- Sachin Save - Design Engineer, BKC office
- Manoj Diwakar - Design Engineer, BKC office
- Aditya Bidikar - Design Engineer, BKC office
- Moosa M - Design Engineer, BKC office
- Vaibhav Dahivalkar - Site Engineer, BKC office
- Pravin Sutar - Draftsman, Fort Office

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