

L&T Earthmover News

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Electrical and Mechatronics on Earthmoving machines – III

In the previous issue, we had dealt with the basic laws of electricity. In this issue we shall focus on some basic electrical systems on earthmoving machines and know what and how of Mechatronics.

MECHATRONICS is a word derived from two words **MECHANISM** and **ELECTRONICS**. Simply speaking it means electronic controls of mechanical systems. Today Mechatronics is gaining popularity and acceptance in all fields of engineering and its application finds place from a toy to complex robot or spacecraft; Earthmoving machines are no exceptions. It has spread its wings to such an extent that a 15-20 page chapter in a book of applied electronics 15-20 years back, has become a separate branch of engineering today. It is being taught and studied in all major engineering colleges and technical institutions.

Man has always aspired to make machines that work like a human being. The machine should understand the operating conditions and needs and control itself as a logical person would, if faced with a similar situation. The basic structure of Mechatronics consists of ...



The sensors pick up the operating conditions or instructions from the operator and send it to the controller. The controller processes these inputs and gives a logical output, which either adjusts the systems automatically or sends caution signal to the operator or both,

depending on the gravity of situation. It is akin to the functioning of the human body, where the sense organs give inputs to the brain, which processes these input signals and gives logical (sometimes illogical or humorous too) instructions to our limbs to respond to the stimuli. The function of the controller in a Mechatronics is similar to the function of our brain. The sensors used on machines excel human senses in measurable range and accuracy. The response from the controllers is logical, precise and works at the speed of light.

From the user point of view, Mechatronics features help to extract high productivity, good fuel economy while providing pleasant operation and enhanced operator's comfort. Features like working mode selection, pump and engine mutual control, power maximizing function, auto deceleration etc., provide high productivity and optimize on fuel economy. While features like fuel control dial for engine throttle control, automatic engine warm up and overheat prevention system, self diagnostics, oil maintenance functions etc., offer excellent operator comfort, safety to the machine and even drastically lowers the fault

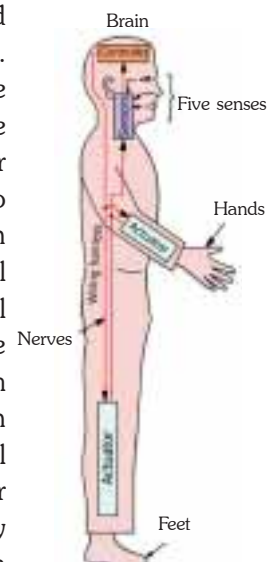
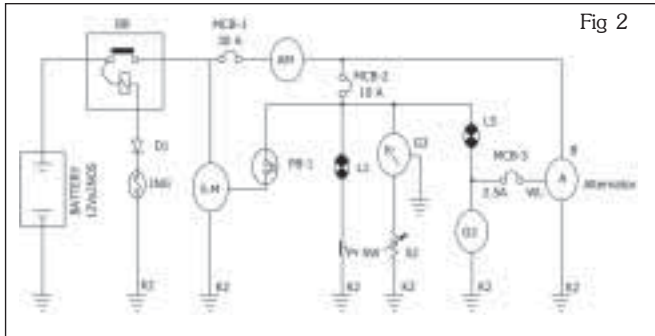


Fig 1

diagnosis time should there be any. Mechatronics clubbed with electrical and hydraulic systems are becoming an integral part of all modern earthmoving machines.

The fig. 2 below shows a conventional starting circuit of an excavator.



Conventional starting circuit.

2 Batteries of 12 Volts each are connected in series to form the 24V circuit. The circuit is divided into branches protected by a miniature circuit breaker (MCB). MCB trips if there is a short-circuit in the wiring harness or a current higher than the rated capacity of the MCB flows through the circuit. This also helps in troubleshooting, as the fault would be within the branch that is controlled by the MCB. The battery relay (BR) separates the battery from the entire machine and is like the main switch in our homes. This relay is actuated by the ignition key (ING) placed on the operator's console. With the ignition key OFF, there is no electrical supply to any part of the machine, eliminating the possibility of short-circuit when the machine is not in use or during maintenance. A thick cable connects the battery relay to the starter motor directly, while supply to all other loads pass through the ammeter (AM). The ammeter measures the discharging and charging current and indicates the charge level of the battery. The start button is connected in series with solenoid coil of the starter motor. When the ignition key is switched ON power is available at all points where the circuit is complete. The field coil of the alternator is connected in series with "Battery not charging indicator". With the ignition key ON, power is available to the alternator field coil, which excites it (induces electromagnetism). The indicator glows showing that the battery is getting discharged. If other electrical loads are switched ON, the current that passes through the ammeter deflects its needle in the negative direction, showing the magnitude of the discharged current.

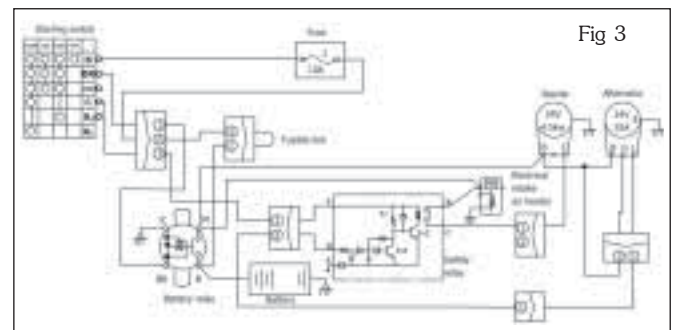
When the engine starts, the alternator also runs and voltage is generated at the "B" terminal. The generated voltage is around 27.5 V. During cranking, the terminal voltage of the battery reduces to around 20-21 volts

due to the large current flowing to the starter motor. Due to this potential difference between the battery and the alternator, current flows from the alternator to the battery. The magnitude depends on the internal resistance of the battery and the voltage difference.

Initially, as the voltage difference is high, a large current flows towards the battery (around 15-20 ampere) and the ammeter needle deflects in the positive direction to indicate charging of the battery. The "WL" terminal of the alternator also has the same voltage as the "B" terminal. The same voltage acts on both ends of the "Battery not charging indicator", and as there is no voltage difference across its ends, the indicator goes OFF. The operator understands that the battery is getting charged. As current flows to the battery and it gets charged, its terminal voltage increases. As the voltage difference between the alternator and battery terminal reduces, the charging current also reduces and becomes close to zero after sometime. The ammeter needle also comes to zero, indicating that the battery is fully charged.

While the engine is running, if the ignition key is turned OFF, battery relay is also turned OFF. The charging circuit from the alternator to the battery is disconnected due to the break in continuity and charging stops. Hence, operators are advised not to switch OFF the key as long as the engine is running. Similarly, pressing the start button on a running engine will supply current to the starter motor. The pinion will try to engage with the flywheel ring gear and can cause damage to the starter motor and flywheel. Operators have to be careful to avoid this mistake.

These deficiencies are overcome in the starting circuit for PC200-6 shown below.

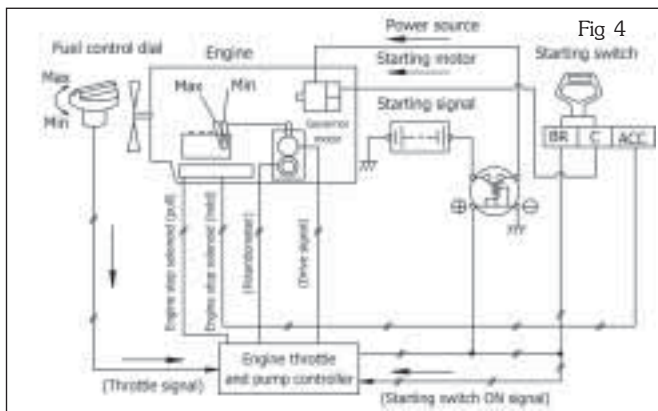


Block diagram of PC200-6 starting circuit.

Here, a starter safety relay is placed between the ignition key and the starter motor. The ignition key has 4 positions - HEAT- OFF-ON- START. This eliminates the need of an additional start button. The position "ON to START" is spring-loaded and the key springs back to ON from START when it is released as soon as the engine starts. The semiconductor safety relay does not allow power to go to the starter motor solenoid if

the engine is running and, hence, the starter motor cannot operate. During starting, when the ignition key is turned to START, power from the C terminal of the ignition key goes to the S terminal of the safety relay. This supply energises the coil of the safety relay through the transistor Tr2 shown in fig 3. With the coil energized, the contact B-C closes and battery power at B terminal goes to the starter motor C terminal and engine starts. As the engine starts, alternator generates power and its output voltage acts at the R terminal of safety relay. Once the generated voltage exceeds the zener voltage, it switches OFF the transistor Tr2 by switching ON transistor Tr1. As long as transistor Tr2 is switched OFF, the relay coil cannot be energized. Thus, even if the starting switch is turned to START, starter motor will not get supply at the C terminal to crank the engine. The fear of damaging the starter motor through re-cranking by mistake is ruled out. This also eliminates the risk of damaging the starter motor if the ignition key is not released immediately after the engine has started. Supply from the alternator is also used to keep the battery relay ON as long as the engine is running. Therefore, even if the ignition key is removed for either opening the fuel cap or the pump compartment with engine running, charging circuit is not disturbed. Provision of the starter safety relay has added to the safety of the machine and is a user friendly feature too.

There is a throttle lever for controlling engine speed and stopping the engine.



Engine control circuit as used on PC300 LC-7.

The system consists of a controller, a throttle dial for changing engine speeds and a governor motor on the fuel pump to actuate throttle lever. The engine can be started and stopped by the starting switch. There is no throttle cable or a separate stop cable. The controller has been programmed for various speed parameters depending upon the throttle dial position and the operating mode selected.

The throttle dial is a potentiometer with the dial calibrated from minimum to maximum engine speed and when the operator selects a speed position it gives a voltage signal as input to the controller. The governor motor is

a permanent magnet stepper motor and its output shaft is connected to the throttle lever of the fuel pump. According to the drive signal from the controller it can move the throttle lever in definite angle to control engine speed. It has a feedback potentiometer, which sends an input to the controller to indicate the final position of the motor.

When the starting switch is turned to the START position, current flows to the starter motor and the engine starts. The starter motor is fitted with a safety relay, which works in the same manner as explained in the above paragraphs. As the engine starts, the controller checks the signal from the fuel control dial and sets engine speed in accordance with the fuel dial position. As the fuel dial position is changed from MIN. to MAX. the controller calculates the angle of the governor motor according to the signal, and sends a drive signal to adjust the angle. The operating angle is detected by the feedback potentiometer, and it sends a signal to the controller, so that it can observe the operation of the governor motor.

The operator can change engine speed by just turning the throttle dial and the controller instructs the governor motor to respond to the operator's request immediately. The controller is a minicomputer and also receives signals from pressure switches on the Pressure Proportionate Control (PPC) lines. The controller is so programmed that if none of the PPC levers are in operation for a predetermined time the engine speed automatically reduces to an intermediate speed of around 1400 rpm to save on fuel consumption and noise. Once the control levers are operated the engine speed raises to the preset level within a second. This is known as auto deceleration function. This can be deactivated by the press of a button. Features like pump engine mutual control, swing control function, automatic travel speed selection functions are possible with ease. The controller also provides self diagnostic features which identify abnormalities in the machine, records them, provides caution to operators and even informs the area of abnormalities, so that troubleshooting and repair time is reduced and machine uptime is enhanced.

Mechatronics has opened new avenues in automation and controls of earthmoving equipment. The features adopted make these sophisticated machines very easy to operate and maintain. Dependence on experience in troubleshooting and detailed knowledge of working system has reduced, as machines have been made more intelligent for extracting the maximum from them.

This concludes our series on Electricals and Mechatronics. In the next issue, we shall deal with something equally interesting related to earthmoving machines. Please keep track of the L&T Earthmover News. You may send your feedback to emst-bw@bw.ltindia.com

For the benefit of customers of Construction & Mining Equipment Business Unit (CMB), Training Programmes offered by L&T, have

	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W
May 2006		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
June				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
										4/L&T 72/90-3/B'lore Mechanics/Supervisors								
										5/Highway Project Machines/ Itawa Operators/Mechanics						6/PC200-6/PC300-7/Gurgaon Operators/Mechanics		
July	30	31				1	2	3	4	5	6	7	8	9	10	11	12	13
										13/PC200-6/B'lore Engineers/Foremen								
																	14/PC200-6/Mumbai Operators/Mechanics	
August		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		21/L&T 300/B'lore Engineers/Foremen								22/Kom. Wheel Loader /B'lore Engineers/Foremen								
September					1	2	3	4	5	6	7	8	9	10	11	12	13	14
										28/PC400-7/B'lore Engineers/Foremen								23/PC200-6/Operators
												29/PC200-6/PC300-7/Delhi Operators/Mechanics						
October	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			35/L&T 170/180/B'lore Engineers/Foremen								36/Kom.Grader/ B'lore Mechanics/Supervisors				38/PC71/B'lore Mechanics/Supervisors			
												37/PC300-7/Rajahmundry Operators/Mechanics			39/PC200-6/ Jabalpur Operators/Mechanics			
November			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
									42/L&T 300/B'lore Mechanics/Supervisors									
December	31				1	2	3	4	5	6	7	8	9	10	11	12	13	14
									48/L&T 300 Trouble-Shooting/B'lore Engineers/Foremen							50/Excavator Operators		
										49/L&T 72/90-3/B'lore Mechanics/Supervisors								51/Operator
January 2007		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			54/PC200-6/B'lore Mechanics/Supervisors							55/Kom. Wheel Loader /B'lore Mechanics/Supervisors								
February				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								58/L&T 300/B'lore Engineers/Foremen										
										59/Kom. Machine Electricals /B'lore Mechanics/Supervisors								

Key for Course Fee:

Special programme for Managers / Executives / Engineers & Foremen : Rs. 2,000/-
 Programme for Engineers & Foremen : Rs. 1,750/-

Programme for Mechanics & Supervisors
 Programme for Operators & Mechanics

Note: For course contents, please see page no. 2

Kom : KOMATSU; B'lore : Bangalore

been scheduled in Bangalore and other Service Stations. Table below gives the Training Schedule for the period April 06-March 07

	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
7	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
						1/L&T 300/B'lore Mechanics/Supervisors						3/PC200-6/ PC300-7 /Bhubaneshwar Operators/Mechanics						
							2/PC200-6/B'lore Mechanics/Supervisors											
4	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
	7/PC300-6&7/B'lore Mechanics/Supervisors						9/L&T 300 Trouble-Shooting/B'lore Engineers/Foremen						12/PC600-6&7/PC1250-7/B'lore Engineers/Foremen					
rahaf s		8/PC200-6/Goa Operators/Mechanics							10/L&T 72/90-3/Kochi Operators/Mechanics				11/L&T 72/90-3/Gwalior Operators/Mechanics					
2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
	15/Kom. Dozer/B'lore Engineers/Foremen							18/Kom. Engines/B'lore Mechanics/Supervisors						19/L&T Excavator Electricals/B'lore Mechanics/Supervisors				
l s	16/Highway Project Machines/ Gorakhpur/ Operators/Mechanics					17/PC200-6/Chennai Operators/Mechanics											20/PC200-6/Kochi Operators/Mechanics	
5	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			
	24/PC200-6/ Raigarh Operators/Mechanics						26/PC130-7/B'lore Mechanics/Supervisors											
C200-6/ Kolkata Operators/Mechanics	25/PC200-6/PC300-7/ Jalpur Operators/Mechanics											27/PC200-6/90-3/ Pune Operators/Mechanics						
3	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
	30/L&T 300(E)/B'lore Engineers/Foremen/HT Electricals							33/PC200-6/B'lore Mechanics/Supervisors						34/Excavator Hyd. Systems/B'lore Engineers/Foremen				
		31/PC200-6/Ahmedabad Operators/Mechanics					32/PC71/B'apur Operators/Mechanics											
3	19	20	21	22	23	24	25	26	27	28	29	30	31					
rs							40 /PC300-6&7/B'lore Engineers/Foremen											
								41/L&T 72/90-3/ Chandigarh Operators/Mechanics										
5	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
	43/PC200-6/B'lore Engineers/Foremen							45/PC600-6&7/PC1250-7/B'lore Engineers/Foremen						47/ Surface Miner-KSM 304 /B'lore Engineers/Foremen				
		44/PC300-7/Udampur Operators/Mechanics							46/PC300-7/ Ongole Operators/Mechanics									
3	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
avator Hyd. Systems/B'lore Engineers/Foremen							53/Kom. Dozer /B'lore Mechanics/Supervisors											
/90-3/ Rourkela Operators/Mechanics					52/PC200-6/Hubli Operators/Mechanics													
7	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
	56/Kom. Engines/B'lore Engineers/Foremen							57/PC130-7/B'lore Engineers/Foremen										
4	15	16	17	18	19	20	21	22	23	24	25	26	27	28				
	60/PC200-6/B'lore Engineers/Foremen							61/PC300-6&7/B'lore Mechanics/Supervisors										
								62/L&T 300/Durgapur Mechanics/Supervisors										

Supervisors : Rs. 1,500/-
Mechanics : Rs. 750/-



LARSEN & TOUBRO LIMITED
Construction & Mining Equipment Business Unit
Product Support Department
Bangalore

V. Prabhakar Reddy: Contractor par Excellence



Mr. V. Prabhakar Reddy, a contractor *par excellence* with a turnover of Rs. 100 crore now, sits back and reminisces about his early years in the business. “Mica mining was our family business. When the industry was not doing well, we had to look for more avenues. Since mining was the main foray

for us, we diversified the operation in a small way into the construction business. Initially it was a labour-oriented construction contract in Wardha district at Maharashtra and it continued till 1985,” he discloses. “During this time I came across L&T 90 hydraulic excavator and was impressed with its performance, thus the first L&T 90 machine was purchased in the year 1987.”

“It was not easy to own a machine in those days for a reasonably new comer in the field, but L&T supported me a lot,” Mr. Reddy recalls fondly. “We have grown together ever since,” he discloses. “With my dedication and commitment supplemented by machine power to deliver, the business has grown multifold. After the mechanization of work, I have taken a contract job at Sree Sailam Left Bank Canal at Nalgonda in Andhra Pradesh. With the timely completion of the quality work, I gained a lot of confidence to execute bigger jobs.”

“Overburden removal at coalfields in those days was carried out by the same organization and this was not economical for them for various reasons,” he points out. “Thus, we ventured into this potential area as a trend-setter. It proved to be beneficial to both. This was a turning point in my life. Though we were entering into a new line of business, we were aware that the potential was very high though the challenges were many,” he recalls. “With the ever increasing demand, we kept on adding the machines. Thus in the year 1987 we had taken twelve L&T 90 machines.” he reveals proudly.

“The real take-off point in my life was in the year 1989, when we started the coal field overburden removal job. It was to the advantage of the organization and us. The

economy was opening up and the demand was increasing; in tune with this, we started mechanizing the operations and also added capacity,” he asserts.



To supplement the core business, Mr. Reddy started taking contracts on irrigation jobs. The GNSS flood flow Canal worth Rs. 150 crore, was completed in one and a half years (though the completion period was two years). Another irrigation project, worth Rs. 70 crore, was in Sangambada right bank in Andhra Pradesh.



Mr. Prabhakar Reddy feels comfortable with mining contract jobs, as it has lesser hassles. With a staff strength of over 1000 including those at various sites, Mr. Reddy monitors the activities from his residence at Chennai or from the head office at

Hyderabad. His team sends him daily the performance report on the projects, which he peruses for updating the day-to-day activities.

Mr. Reddy recalls his school days and observes, “The discipline and the commitment I learnt at Rishi Valley School is infused into my blood and helps me even now. I get up early in the morning and attend to all my callers without making them to wait. I trust our people and most of them are with me from the day of inception of the company. Loyalty plays a major role.” Over the years, as the business has grown, the staff strength has



also grown.

Mr. Prabhakar Reddy’s initial education was at Rishi Valley and then at Loyala College at Chennai. After the completion of Bachelor of Arts, Mr. Reddy started his business. Mr. Reddy used to spend weeks/months together at worksites. “I stayed in the worksites and had the common facility as everyone gets in the site; hence,

nobody will give me any excuse. I am punctual and also disciplined to answer their queries irrespective of the time and place. I get the daily report from the site. I need not be required to be present all the time at the site. The setup is taking care of it," he says.

Now, with a fleet of twelve PC300, two PC600, and two each of L&T 90, L&T 300 Hydraulic Excavators and Komatsu graders beside other makes in the fleet of construction machines, Mr. Reddy is poised to take on any challenging jobs. Being more familiar with Komatsu machines Mr. Reddy opines, "Komatsu machines are technologically superior and also workhorses. My machines are operating in three shifts and clock around 6000 hours in a year. We are contemplating to replace some other models also with PC400 machines."

On the machine operator's qualification, Mr. Reddy quickly reacts saying that the operators have graduated from smaller jobs. "We provide facilities for employees to grow with the organization. The present machine operators are either the original operators from day one who remained with us or graduated from some other jobs. We firmly believe in operational training."

On the jobs taken at different locations, Mr. Reddy with his experience at Mizoram, has a different version. "We had taken up a job at Mizoram, but lost heavily in that project because of mismanagement. We cannot control



the activities, which are away from South India, as the travel time is excessive, besides unexpected rescheduled flight timings. We cannot line up any activity on a tight schedule. Hence, we have now withdrawn from this project."

Having been, satisfied with his achievements, Mr. Reddy feels that charitable activities may bring more personal satisfaction to him. Some of the projects he is involved in are: an orphanage for deaf and dumb, a crematorium (which was unavailable) in Nellore, his hometown, and providing a scanner for the hospital for the needy.

"We have also adopted a village for educational purposes in a unique way. Here, the teachers are teaching after their school time."

Mr. Reddy's future plan is to have an old age home with modern facilities. According to him, it should come up in 2006 in Chennai. "It should be with one of the top facilities. We are also in dialogue with hospitals for the medical facilities."

Mr. Reddy's main hobby is meeting his childhood friends. So, he has organized an 'Old Students Meet' to provide an opportunity to meet everybody. "Though we are all in different walks of life now, we can recall old memories," he maintains.



Japanese TV Crew

A team from Japan's popular TV Channel - **Asahi**, was in Bangalore in connection with a documentary film for broadcasting in Japan. They have selected a few organizations and accordingly visited L&T-Komatsu Limited at Bangalore, on February 16, 2006.

Subsequently, the TV crew visited Mr. V. Prabhakar Reddy's site at Anantpur for video shooting of L&T-Komatsu and Komatsu machines working in the irrigation project.



Hindustan Construction Company



(L to R) Mr. S.K. Mitra, General Manager, Construction & Mining Equipment Business Unit, L&T, Mr. G.J. Dandiwala, Senior Executive, HCC and Mr. Robert Allen, Vice-President – P&M, HCC sharing a lighter moment



(L to R) Mr. K.S. Murali, Dy. Chief Engineer (E), HCC, Mr. A.K. Garg, Head, Construction Equipment Business, L&T, Bangalore, Mr. A.K. Sharma, Zonal Manager, L&T-Pune, Mr. Ashok Khare (Procurement Division), HCC and Mr. Arun Karambelkar, GM (Procurement), HCC in discussion during the customer meet

Hindustan Construction Company Limited (HCC), a leading construction and infrastructure development company with rich experience in executing construction projects, is one of L&T's most esteemed and important customers. Though HCC started initially with tunnelling works, it has today grown to a Company with a dedicated, experienced and expert team of people achieving remarkable feats in the field of civil engineering construction. With its diversified activities such as power, roads and bridges, dams and barrages, marine works, buildings and environmental projects, HCC has established itself as one of the acknowledged firms.

HCC has, over the years reposed faith in L&T for their requirements of various Construction Equipment and built a large fleet of L&T-Komatsu hydraulic excavators that are deployed at their various projects.

L&T had recently arranged a meeting with HCC, at Mumbai to understand HCC's business plans and ascertain the action required to improve its product offering to HCC. It was attended by senior HCC officials – Mr. Robert Allen, Vice-President P&M, Mr. S.P. Rajan, Dy. Chief Engineer (Equipment), Mr. Arun Karambelkar, General Manager (Procurement), Mr. G.J. Dandiwala, Sr. Executive, Mr. Menghani, Dy. Chief Engineer (Equipment), Brig. S.G. Wagle, Dy. Chief Engineer (Equipment).

This meet provided a platform for a close interaction with the HCC team and understanding their perceptions and expectations for further strengthening, the long-standing business association between HCC and L&T.

“Service Engineer – the most dependable Friend of Customer”



Mr. Nino John

Product Support Department (Dealership Cell) had conducted an Essay Contest for our Dealers' Service Engineers, during March 2006. The topic given was 'Service Engineer – the most dependable friend of customers'. There was good response from our Dealers' Service Engineers.

We have adjudged the essay submitted by Mr. Nino John, the best. Mr. Nino John is working with our Dealer M/s. Cinzac Corporation, Kochi.

L&T Earthmover News congratulates him on winning the essay contest and wishes him success in his future endeavours.

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