SELECTION OF EQUIPMENT AND PROJECT ENGINEERING FOR OPTIMIZING CIVIL AND STRUCTURAL COST

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ABSTRACT

The cement plant capacities have come a long way leading to the present plant capacities. In recent years, the quantum of civil and structural costs has grown disproportionately in respect to the percentage of over all cost.

This necessitates the need of proper plant equipment selection and project engineering leading to the savings in civil and structural cost and close coordination among various functional departments to optimize the building size and shape.

1.0 SUMMARY

Based on **HOLTEC**'s in depth experience, it is possible and desirable to reduce civil and structural costs in certain areas by adopting the cost effective solutions of project engineering. The areas covered in this paper as case studies are:

a) Selection of proper design of reclaimers:
b) Location for raw mill/kiln chimney
c) Location of kiln feed bin
d) Locating the calibration point for weigh feeders in grinding systems
e) Construction technology for large capacity silos
f) New technology of receiving and unloading raw materials and solid fuels through trucks
g) Limestone crushing structure optimization

2.0 CASE STUDIES

Case studies have been carried out for above areas and the details have been provided below:

1. Selection of proper design of reclaimers

In general, the following two designs of side reclaimers are available:

a) Ascending trough design reclaimer, without retaining wall
b) Inclined reclaimer, with retaining wall

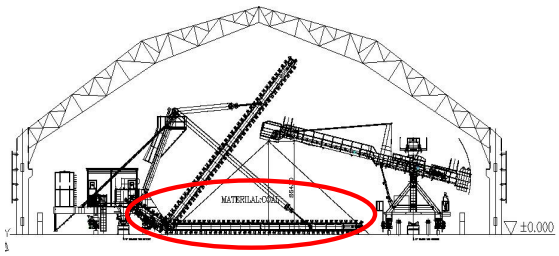
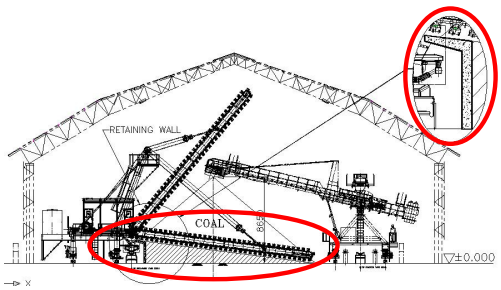
a. Ascending trough design reclaimer, without retaining wall	b. Inclined reclaimer, with retaining wall
	

Fig-1 : Two designs of Side Reclaimers

Considerations: This case study deals with a typical coal stockpile with side scraper reclaimer of both of the above designs:

	a. Ascending trough design reclaimer, without retaining wall	**b. Inclined reclaimer, with retaining wall**
Material	Coal	Coal
Pile Capacity	2 x 6,000 t	2 x 6,000 t
Reclaiming cap.	75 tph	75 tph
Pile ht. x width	8.6 m x 20.6 m	8.6 m x 17.8 m
Shed dimensions	47 m x 228 m = 10,716 m2	40.5 m x 286 m = 11,583 m2

Cost comparative: Below cost comparative is self explanatory:

	a. Ascending trough design reclaimer, without retaining wall		**b. Inclined reclaimer, with retaining wall**	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / stru. incl. shed:				
Earthwork	4,050 m3	14,17,500	5,050 m3	17,67,500
PCC	185 m3	7,40,000	230 m3	9,20,000
RCC	1,900 m3	1,14,00,000	2,300 m3	1,38,00,000
Formwork	6,200 m2	43,40,000	7,800 m2	54,60,000
Reinf. steel	515 t	1,43,60,000	354 t	1,77,10,000
Structural steel	515 t	3,60,82,368	555 t	3,88,51,613
CGI sheet	15,960 m2	1,11,72,000	20,020 m2	1,40,14,000
Misc (5%) Rs	-	39,75,593	-	46,26,156
Retaining wall	-	-	270 RM @ Rs 120,000 / RM for avg. depth of 7 m	3,24,00,000
Total civil / stru. cost (Rs)	8,34,87,461		12,95,49,268	
Additional Eqpt. Cost (Rs)	30,00,000		0	
Total cost (Rs)	8,64,87,461		12,95,49,268	
Cost Saving (Rs)	4,30,61,807; **Say 43 million**			

Conclusion: Generally, the inclined reclaimer with retaining wall shall be used where there is space restriction.

However, it is to be noted that the cost of retaining wall is extremely high especially in the area where the foundation depths are more or soil is weak. Hence it is always advisable to go for the ascending trough design reclaimer.

2. Location for raw mill/kiln chimney

Chimney for raw mill / kiln bag house can be:

a. Steel chimney supported with preheater tower ; or
b. Standalone chimney:
    i. Standalone (semi-guided) steel chimney ; or
    ii. Standalone (self supported) concrete chimney with fire brick lining

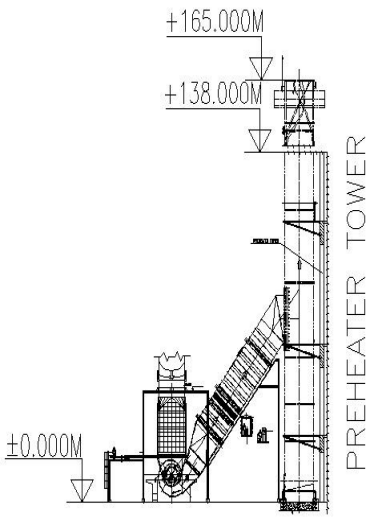
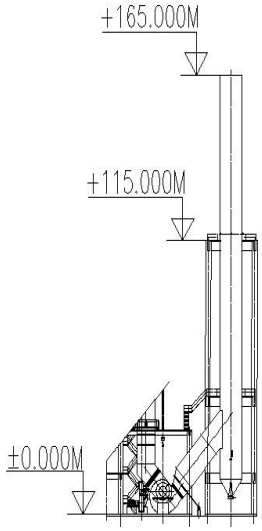
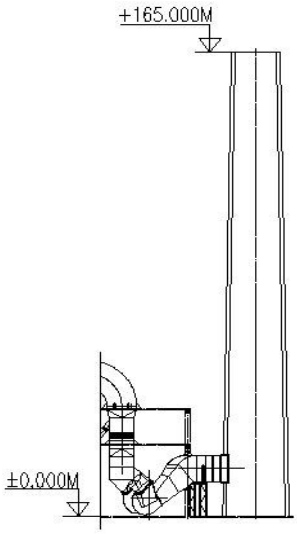
a. Steel chimney supported with preheater tower	**b-i. Standalone (semi-guided) steel chimney**	**b-ii. Standalone (self-supported) concrete chimney**
		

Fig-2 : Two locations of raw mill / kiln chimney

The chimney height is governed by preheater height, whether it is supported with preheater or it is standalone one. This case study has been done on a typical chimney with either of the above options.

Considerations: Chimney height : 165 m; Dia: 5.6 m, Foundation : RCC

Advantages and disadvantages of these options are:

S. No.	**a. Steel chimney supported with preheater tower**	**b-i. Standalone (semi-guided) steel chimney**	**b-ii. Standalone (self supported) concrete chimney**
1.	Lower cost, due to saving in chimney shell, foundation and supports cost	High cost	Substantially high cost
2.	Construction period is substantially low	Construction period is high	Construction period is very high
3.	Easy accessibility to chimney by PH lift / staircase	Separate access for chimney is required	Separate access for chimney is required
4.	No fire brick lining and acid-resistant required, acts as duct	Fire brick lining and acid resistant not required	Fire brick lining and acid resistant required
5.	Bag house with same side inlet and outlet, resulting in marginal increase in cost	Bag house with inlet and outlet on opposite side	Bag house with inlet and outlet on opposite side

HOLTEC has done engineering for many plants worldwide, where main chimney has been supported with preheater tower.

Cost comparative: Below cost comparative is self explanatory:

	a. Steel chimney supported with preheater tower		**b-i. Standalone (semi-guided) steel chimney**		**b-ii. Standalone (self supported) concrete chimney**	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / stru.:						
Earthwork	300 m3	1,05,500	1,750 m3	6,12,500	1,140 m3	3,99,000
PCC	6 m3	24,000	30 m3	1,20,000	25 m3	1,00,000
RCC	115 m3	6,90,000	1,800 m3	1,08,00,000	2,851 m3	1,71,00,000
Formwork	150 m2	1,05,000	6,750 m2	47,25,000	190 m2	1,33,000
Slipform	0	0	0	0	9,025 m2	67,68,750
Reinf. steel	20 t	9,77,000	360 t	18,00,000	570 t	2,85,00,000
Structural steel	500 t	35,00,000	500 t	35,00,000	115 t	80,50,000
Fire brick	0	0	0	0	1,425 t	1,71,00,000
Acid resistant	0	0	0	0	1,378 t	1,92,85,000
Painting	Lumpsum	20,00,000	Lumpsum	20,00,000	Lumpsum	25,00,000
Misc (5%) Rs	-	19,45,075	-	35,62,875	-	49,96,788
Total civil / stru. cost (Rs)	4,08,46,575		7,48,20,375		10,49,32,538	
Additional cost of bag house with same side inlet, o/l (Rs)	60,00,000		0		0	
Total cost (Rs)	4,68,46,575		7,48,20,375		10,49,32,538	
Cost Saving(Rs)	With Option a: 5,80,85,963; **Say 58 million** (over option b-ii) With Option a: 2,79,73,800, **Say 28 million** (over option b-i)					

Conclusion: It has been evolved that there shall be substantial saving in civil / structural cost and construction time of chimney, if it is supported with preheater.

3. Location of kiln feed bin

Kiln feed bin can be located:

a. In the space available in preheater tower at first floor

b. Underneath blending silo

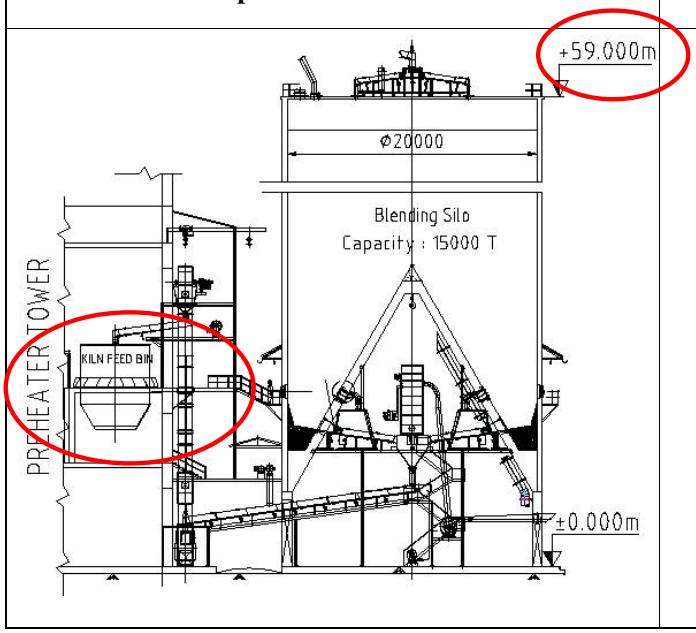
a. Kiln feed bin in preheater tower at first floor	b. Kiln feed bin below blending silo
	

Fig-3 : Two locations of kiln Feed Bin

This case study deals with a typical kiln feed bin located in either of above locations.

Considerations: Raw meal silo : 15,000 t; Dia : 20 m; saving (with option b) in silo height and silo feed bucket elevator height: 11 m; new bucket elevator requirement (21 m c-c) for kiln feed bin feeding (with option a) and an additional bag filter required (with option a)

Advantages and disadvantages of these options are:

S. No.	a. Kiln feed bin in preheater tower at first floor	b. Kiln feed bin below blending silo
1.	Lower civil cost, due to considerable reduction in silo height	Higher civil cost
2.	Slightly higher mechanical equipment cost due to additional bucket elevator and increase in air slides length, part of which gets compensated by reduced raw meal silo feed bucket elevator height	Slightly lower mechanical equipment cost
3.	Slightly increased specific power consumption, part of which gets compensated by reduced raw meal silo feed bucket elevator height	Slightly lower specific power consumption
4.	Fair amount of working space available around kiln feed bin in better conditions	Available working space is less in hot conditions
5.	Construction period for silo is less	Longer construction period for silo

Cost comparative: Below cost comparative is self explanatory:

	a. Kiln feed bin in preheater tower at first floor		b. Kiln feed bin below blending silo	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / stru:				
Earthwork	2500 m3	8,75,000	3500 m3	12,25,000
PCC	200 m3	8,00,000	225 m3	9,00,000
RCC	4,500 m3	2,70,00,000	5,300 m3	3,18,00,000
Formwork	3,469 m2	24,28,356	4,300 m2	30,10,000
Slip form	7,781 m2	56,02,262	8,700 m2	62,64,000
Reinf. steel	720 t	3,60,00,000	848 t	4,24,00,000
Stru. steel	200 t	1,40,00,000	200 t	1,40,00,000
Misc (5%) Rs	-	43,35,281	-	49,79,950
Total civil/stru cost (Rs)	9,10,40,899		10,45,78,950	
Additional Eqpt. Cost (Rs)	16,00,000		0	
Additional cost of spec. power cons. (for 5 yrs) (Rs) discounted to NPV @ 12%	17,00,000		0	
Total cost (Rs)	9,43,40,899		10,45,78,950	
Cost Saving (Rs)	1,02,38,051; **Say 10 million**			

Conclusion: Overall cost of blending silo can be reduced by suitably locating kiln feed bin in preheater tower first floor

4. Locating the calibration point for weigh feeders in grinding systems

In raw material / clinker grinding systems, calibration point for calibration of weigh feeders can be located:

a. Near mill, from reject bin after re-circulation bucket elevator

b. Underneath mill hopper building, by providing a reversible belt conveyor

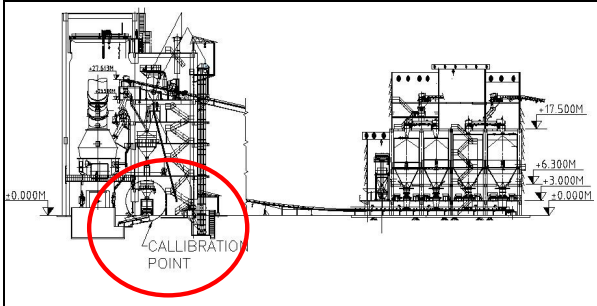
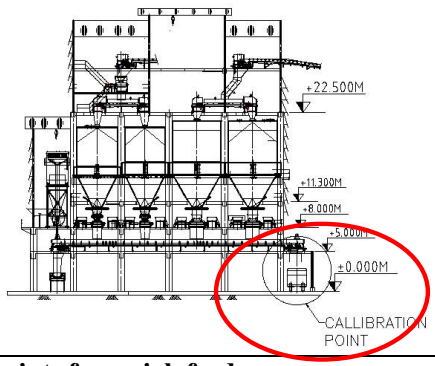
a. Calibration point from reject bin in mill building	b. Calibration point below mill hopper building
	

Fig-4 : Two locations of calibration points for weigh feeders

By shifting the calibration point to reject bin after re-circulation bucket elevator, load bearing mill hoppers building can be lowered down, resulting in reduced civil / structural cost. This will also result in saving of one reversible belt conveyor incl. drive and motor below mill hoppers, de-dusting of one transfer point and marginal saving in specific power consumption.

Considerations: Building size : 31 m x 9 m, Saving in building height (with option b) : 5 m, saving of one reversible belt conveyor below mill hoppers, its drive and one bag filter

Cost comparative: Below cost comparative is self explanatory:

	a. Calibration point from reject bin in mill building		**b. Calibration point below mill hopper building**	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / stru:				
Earthwork	1,300 m3	4,55,000	1,500 m3	5,25,000
PCC	20 m3	80,000	25 m3	1,00,000
RCC	1,750 m3	1,05,00,000	1,900 m3	1,14,00,000
Formwork	6,125 m2	42,87,500	6,650 m2	46,55,000
Reinf. steel	298 t	1,48,75,000	323 t	1,61,50,000
Stru. steel	100 t	70,00,000	135 t	94,15,000
Misc (5%) Rs	-	18,59,875	-	21,12,250
Total civil / stru cost (Rs)	3,90,57,375		4,43,57,250	
Additional Eqpt. Cost(Rs)	0		10,00,000	
Total cost (Rs)	3,90,57,375		4,53,57,250	
Cost Saving (Rs)	62,99,875; **Say 6.3 million**			

Conclusion: By providing calibration point from reject bin near mills, load bearing mill hoppers building can be lowered down, resulting in reduced civil / structural cost as well as equipment cost

5. Construction technology for large capacity silos

Silos can be constructed as:

a. RCC silos, without pre-stressing i.e. conventional silos

b. Pre-stressed silos

This case study deals with cost comparison of typical clinker silos using either of above technology.

a. RCC silos, without pre-stressing	b. Pre-stressed silos
	

Fig-5 : Two locations of raw mill / kiln chimney

Considerations: Clinker silo capacity : 50,000 t; dia : 40 m; height : 40 m

Advantages and disadvantages of these options are:

S. No.	a. RCC silos, without pre-stressing	b. Pre-stressed silos
1.	Lower civil cost	Higher civil cost
2.	Ordinary skilled work force required	Highly skilled execution team required
3.	Construction time is lower	Construction time is higher

Cost comparative: Below cost comparative is self explanatory:

	a. Silos, without pre-stressing		b. Pre-stressed silos	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / stru:				
Earthwork	12,000 m3	42,00,000	12,000 m3	42,00,000
PCC / plum	2,870 m3	1,10,67,500	2,870 m3	1,10,67,500
RCC	7,000 m3	4,20,00,000	7,000 m3	4,20,00,000
Formwork	2,625 m2	18,37,500	2,625 m2	18,37,500
Slip form	12,500 m2	90,00,000	12,500 m2	90,00,000
Reinf. steel	1,050 t	5,25,00,000	945 t	4,72,50,000
Structural steel	200 t	1,40,00,000	200 t	1,40,00,000
CGI sheet	2,000 m2	14,00,000	2,000 m2	14,00,000
Deck plate	28 t	19,60,000	28 t	19,60,000
RR masonry	5,800 m3	1,62,40,000	5,800 m3	1,62,40,000
Pre-stressing work	0	0	150 t	2,25,00,000
Misc (5%) Rs	-	77,10,250	-	86,47,750
Total civil / stru. cost(Rs)	16,19,15,250		18,16,02,750	
Cost Saving (Rs)	1,96,87,500, **Say 19.7 million**			

Conclusion: Large capacity silos can also be constructed without pre-stressing, thus, reducing structural cost and construction time, and eliminates necessity of highly skilled execution team specially for pre-stressing.

HOLTEC has done engineering for many large capacity clinker silos without pre-stressing, for e.g.:

- Binani Cement : 50,000 t, 40 m dia, year 2006-07
- Chettinad Cement : 55,000 t, 40 m dia, year 2006-07
- KJS Cement : 50,000 t, 40 m dia, year 2009-10
- Lafarge, Arasmeta : 40,000 t, 40 m dia, year 2005-06
- OCL Rajgangpur : 40,000 t, 40 m dia, year 2007-08
- Soufian Cement Company, Iran : 45,000 t, 40 m dia, year 2009

Some other silos without pre-stressing designed by **HOLTEC**, under execution are:

- Dungsum Cement Corporation Ltd., Bhutan, Clinker silo : 45,000 t, 40 m dia
- Wonder cement Ltd., Clinker silo : 40,000 t, 40 m dia

Some clinker silos with pre-stressing designed by **HOLTEC** are:

- Binani Cement : 40,000 t, 35.5 m dia, year 1995-96
- Chettinad Cement : 40,000 t, 35.5 m dia, year 1999-00
- Grasim Cement (Grasim South plant): 40,000 t, 35.5 m dia, year 1998-99
- Grasim Cement, Kotputli : 1,50,000 t, 65 m dia, year 2007-08
- National Cement Company, Yemen : 45,000 t, 35.5 m dia, year 2006-07
- Zuari Cement : 91,000 t, 60 m dia, year 2006-07

6. New technology of receiving and unloading raw materials and solid fuels through trucks:

Bulk materials by trucks can be received by:

a. Truck tippler and Box type feeders

b. Truck tippler, underground hopper (in RCC and / or steel construction), followed by apron feeder and belt conveyor

Conventional system used for receiving materials is underground dump hopper followed by apron feeder and belt conveyor in tunnel. A box type feeder is a combination of an inclined apron-belt with an in-built horizontal box for receiving materials. In conventional system, an additional belt conveyor is also required to convey material out of tunnel, which results in an additional transfer point and venting point. Both of above systems can be integrated with truck tipper, as per requirement.

a. Box type feeder	**b. Underground hopper followed by apron feeder**
System comprises of : ♦ Truck tippler ♦ Box feeder ♦ Small ramp	System comprises of : ♦ Truck tippler ♦ Dump hopper (underground) ♦ Ramp ♦ Apron feeder ♦ An additional belt conveyor ♦ Tunnel

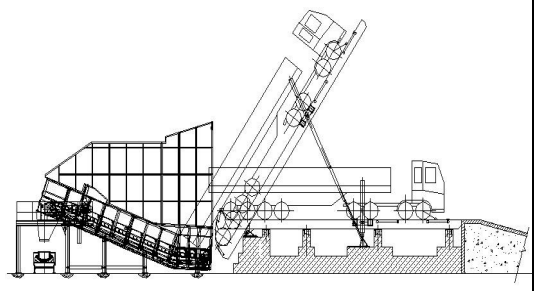
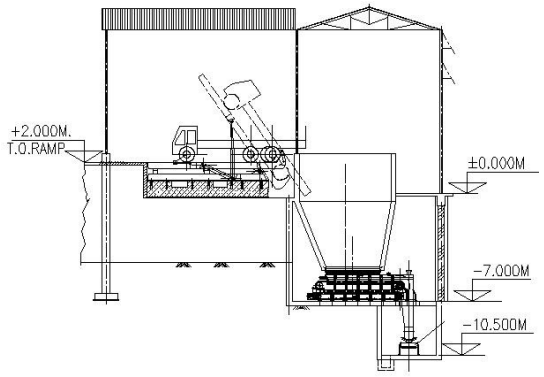
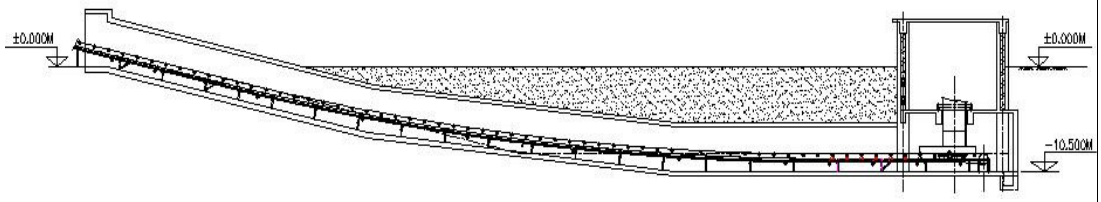
a. Box type feeder	b. Underground hopper followed by apron feeder
	
	

Fig-6 : Receiving and unloading raw materials and solid fuels through trucks

Considerations: Hopper / receiving capacity ~ 20-30 m3, Conveying capacity : 200 tph; Material : Coal; Belt conveyor (with Option b) 70 m in tunnel, 30 m above ground (covered)

Advantages and disadvantages of these options are:

S. No.	a. Box type feeder	b. Underground hopper followed by apron feeder
1.	Very low civil cost	Substantially higher civil cost
2.	Equipment cost low	Equipment cost high
3.	Negligible underground construction	Comparatively huge underground construction
4.	Construction time is negligible	Construction time is very high
5.	Compact installation, no tunnel	Non-compact installation, large tunnel for apron feeder and belt conveyor
6.	Very low power and operating costs	High power and operating costs
7.	Easy access for maintenance	Access for maintenance difficult
8.	Flexibility of location	Not flexible in location

Cost comparative: Below cost comparative is self explanatory:

	a. Box type feeder		b. Underground hopper followed by apron feeder	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Civil / structural:				
Earthwork	152 m3	53,130	4,200 m3	14,70,000

	a. Box type feeder		b. Underground hopper followed by apron feeder	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
PCC	10 m3	40,000	50 m3	2,00,000
RCC	35 m3	2,10,000	1,100 m3	66,00,000
Formwork	20 m2	14,000	3,900 m2	27,30,000
Reinf. steel	3.5 t	1,75,000	132 t	66,00,000
Structural steel	15 t	10,50,000	40 t	28,00,000
CGI sheet	0	0	650 m2	4,55,000
Belt conveyor (covered)	0	0	30 RM @ Rs 50,000 / RM	15,00,000
Ramp	Lumpsum	400,000	Lumpsum	900,000
Misc (5%) Rs	-	97,107	-	11,62,750
Total civil / stru. cost (Rs)	20,39,237		2,44,17,750	
Eqpt. Cost (Rs)	90,00,000		97,00,000	
Total cost (Rs)	1,10,39,237		3,41,17,750	
Cost Saving (Rs)	2,30,78,513; **Say 23 million**			

On an average, 3 systems are installed for receiving and unloading raw materials and solid fuels in a typical cement plant. Thus, cost saving for a plant shall be 3 x Rs 23 million, i.e. **Rs 69 million**.

Conclusion: Box type feeders can be used in place of underground hoppers and feeders, totally above ground reducing cost of ownership (equipment cost plus civil / structural cost) as well as execution / installation time. Box type feeder is also highly favored in areas, where water table is high.

7. Limestone crushing structure optimization

Optimization in limestone structure is possible with reduction in retaining wall length and volume. This is effectively done by decreasing length of retaining wall and providing wing wall followed by stone pitching / natural slope.

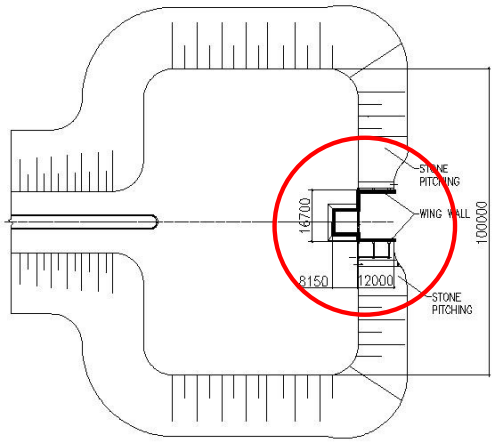
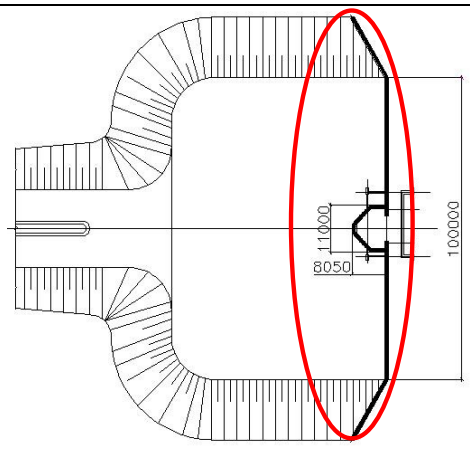
a. Structure with reduced retaining wall	b. Structure with full retaining wall
	

Fig-7 : Limestone crushing structure optimization

Conventionally, retaining wall for limestone crusher ramp is provided across complete width of ramp, on dump hopper side. The size of retaining wall can be substantially reduced by providing wing wall near dump hopper followed by stone pitching / natural slope across remaining width of ramp.

Considerations: Retaining wall for limestone dump hopper with three side dumping; with both the above options. Advantages and disadvantages of these options are:

S. No.	a. Structure with reduced retaining wall	b. Structure with full retaining wall
1.	Low civil cost	High civil cost
2.	Construction time is lower	Construction time is higher

Cost comparative: Below cost comparative is self explanatory:

	a. Structure with reduced retaining wall		b. Structure with full retaining wall	
Parameters	**Quantity**	**Amount Rs**	**Quantity**	**Amount Rs**
Earthwork	150 m3	52,500	1,210 m3	4,23,500
PCC	07 m3	28,000	85 m3	340,000
RCC	500 m3	30,00,000	2,750 m3	1,65,00,000
Formwork	1,000 m2	7,00,000	4,950 m2	34,65,000
Reinf. steel	80 t	40,00,000	440 t	2,20,00,000
Misc (5%) Rs	-	3,89,025	-	21,36,425
Total civil / stru cost (Rs)	81,69,525		4,48,64,925	
Cost Saving (Rs)	3,66,95,400; **Say 37 million**			

Conclusion: It is possible to reduce retaining wall size considerably by optimizing size of retaining wall and off-setting major civil / structural cost towards low cost stone pitching / natural slope.

3.0 BASIS OF COSTING

The following assumptions have been considered while doing the above cost comparison:

S. No.	Parameter	Unit Cost
1.	Earthwork	Rs 350 Per m3
2.	PCC	Rs 4,000 Per m3
3.	RCC	Rs 6,000Per m3
4.	Formwork	Rs 700 Per m2
5.	Slip form	Rs 720 Per m2
6.	Structural steel cost	Rs 70,000 Per t
7.	Reinforcement steel	Rs 50,000 Per t
8.	CGI sheet	Rs 700 Per m2
9.	Deck plate	Rs 70,000 Per t
10.	RR masonry	Rs 2,800 Per m3
11.	Fire brick (for Chimney)	Rs 12,000 Per t
12.	Acid resistant (for Chimney)	Rs 14,000 Per t

4.0 REFERENCES

The following reference projects have been refereed for the Case Studies:

1. Selection of proper design of reclaimers : 3,000 tpd Dungsum Cement Corporation Ltd., Bhutan
2. Location for raw mill/kiln chimney : Reliance Cement Company Pvt. Ltd., 10,000 tpd Integrated Unit, Maihar, MP, India
3. Location of kiln feed bin : 3,000 tpd Dungsum Cement Corporation Ltd., Bhutan
4. Locating the calibration point for weigh feeders in grinding systems : 4,500 tpd Dalmia Cement Ltd. – Kadappa, India
5. Construction technology for large capacity silos : As mentioned in case study above
6. New technology of receiving and unloading raw materials and solid fuels through trucks : 3,000 tpd Dungsum Cement Corporation Ltd., Bhutan
7. Limestone crushing structure optimization : 6,500 tpd Wonder Cement Ltd., Nimbahera, Rajasthan, India

5.0 CONCLUSION AND RECOMMENDATIONS

Net saving with application of all of the above case studies shall be in the order of Rs 250 millions. However, actual cost saving shall depend on case to case basis for each project, concept, capacity etc.