Implementation of Central Bar Bending Yard A Case Study 6x660 MW Sasan UMPP

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***Abstract*— Central Bar Bending Yard (CBBY) is implemented for the first time in India in power plant construction by Reliance at Sasan Ultra Mega Power Project (SUMPP) by use of fully automatic CNC based machines for improved project quality, automated precise rebar processing, low wastage of material and less labor dependency. Salient features, financial benefits and other associated benefits were discussed briefly in this case study.**

Keywords— Implementation of centralised bar bending, CNC based machines, bar bending machines in project, sasan ultra mega power project, power plant construction, innovative methods.

I. Sasan Ultra Mega Power Project [1]

Sasan Ultra Mega Power Project (SUMPP) is an upcoming 3,960 MW pit-head coal-based power plant in Madhya Pradesh. The project is the first domestic coal-based UMPP awarded in the country by the Government of India. Sasan was the first ever integrated-power cum coal mine project. Power generated from the project would be sold to 14 procurers in seven states in the country (Madhya Pradesh, Punjab, Uttar Pradesh, Delhi, Haryana, Rajasthan and Uttarakhand) at a levelized tariff of Rs. 1.196/kwh (Kilo Watt Hour). The low tariff of the project is primarily because of the low cost of generation due to economies of scale, its pit head location and captive mines resulting in better cost control and low financing costs through better financial planning. Further, the project will be employing the advanced 'super-critical' technology for its power plant [2]. This results in higher operating efficiencies and also reduces the emissions thereby making it an environment friendly technology.

II. Introdcution To Rebars And Rebar Processing

A. Rebars and its Importance

A rebar (short for reinforcing bar), also known as reinforcing steel, reinforcement steel or reo bar, is a common steel bar, and is commonly used as a tensioning device in reinforced concrete and reinforced masonry structures holding the concrete in compression [3]. Concrete is a material that is very strong in compression, but relatively weak in tension. To compensate this imbalance concrete's behavior, rebar is cast into it to carry the tensile loads.

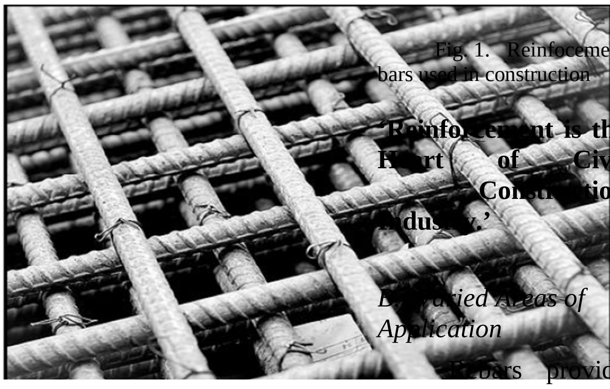


Fig. 1. Reinforcement bars used in construction

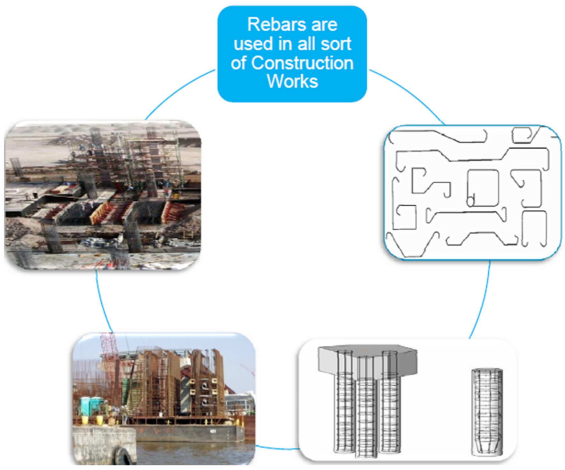
'Reinforcement is the Heart of Civil Construction Industry.'

Diversified Areas of Application

Rebars provide resistance to tensile stresses in the tension side of member. This is the most important function of reinforcement in concrete members.

Fig. 2. Application of rebars in construction work

Reinforcement also resists shear in beams in the form of stirrups. Rebars are used in all sorts of



construction works. The Rebars are bent to required shapes and sizes. The bent bars are then placed in the required areas and then concrete is cast. Different types of structures are built in this manner.

Fig. 1 Reinforcement Bars

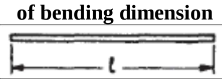
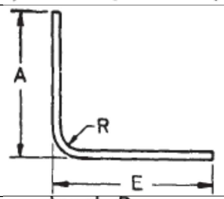
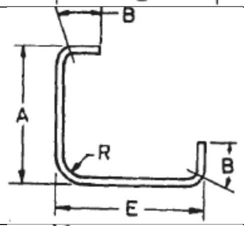
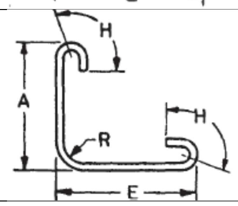
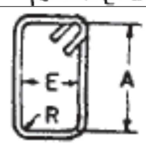
C. Types of steel reinforcement in concrete

Different types of steel reinforcements being using in reinforced concrete structures are Mild steel bars conforming to Indian Standards (IS) : 432, Cold worked steel high strength deformed bars conforming to IS: 1786 (grade Fe 415 and grade Fe 500, where 415 and 500 indicate yield stresses 415 N/mm^2 and 500 N/mm^2 respectively) [4][5]. Thermo Mechanically Treated (TMT) and corrosion resistant steel (CRS) bars are also used. High strength deformed start from 8 mm diameter. The IS specification (IS 1786) specifies nominal sizes of 4,5,6,7,8,10,12,16, 18, 20, 22, 25, 28, 32, 36, 49, 45 and 50 mm.

D. Bar bending

Generally IS 2502: 1999 or British Standards (BS) 8666: 2005 are used as specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete [6] [7]. Bar bending schedules are prepared from drawings or as per requirement of structure using the standards. Bar bending schedule is schedule of reinforcement bars prepared in advance before cutting and bending of Rebars. Steel reinforcement bars are bent to required shapes or cut to different lengths as per bar bending schedule. Measurement of bar bending dimension as per IS 2502: 1999 of some standard dimensions are shown below. Standard shapes of bars to be bent for Reinforced Concretes

TABLE-I Standard shapes of Rebars used in construction [6]

Reference No.	Method of measurement of bending dimension	Approximate total length of bar
A		L
B		A+E-0.5R-D (D=diameter of rebar)
C		A+E-0.5R-D+2B
D		A+E-0.5R-D+2H
E		2(A+E)+24D

E. Forms of Rebar Available in market

The Rebars available in market are generally circular in cross section. Rebars are available in straight form and coil form.

F. Straight Rebars

Fig. 3. Straight Rebars

Straight Rebars are convention form of Rebars and are processed manually or by semi automatic machines by labor. There is huge wastage due to various cut lengths.

G. Coil form Rebars

Fig. 4. Coil form Rebars

Coil form of Rebars cannot be handled manually. Processing of Rebars produces almost nil wastage.

H. Conventional bar bending

Bar bending at site is done from straight bars of conventional steel. Conventional bar bending is done by using semi automatic machines. Following problems are associated with conventional bar bending technique.

- Huge wastage of Reinforcement bars due to various cut lengths.
- Inconsistent / Poor Quality of workmanship.

Fig. 5. Semi automatic machines for bar bending [1]

Fig. 6. Huge wastage of rebar by semi automatic machines [1]

- Poor storage and poor working environment.
- Unsafe to workers.
- Labor intensive and requires huge manpower.
- Requires multiple inventories.
- Large area required for storage of Rebars.

I. Detrimental Effects of poor processing

Rebars lying at ground will result in rusting of reinforcement steel. Rusting and mudding of reinforcement bars causes weak bond with concrete as shown in Fig.7. Loose stirrups at column and joint don't provide requisite confining to the concrete required for triaxial compression.

Fig. 7. Rusting/ mudding of rebars form weak bond with concrete.

III. The Innovative Approach

A. Requisite of a new technology

New technology in bar bending should consider the following parameters

- It should be less labor dependency.
- There should be Low wastage of material.
- Automated mechanism for precise reinforcement bar processing.
- Improved project quality.
- Reduction in project cost and time savings

B. Centralised Bar Bending Yard

Centralized bar bending was implemented in India for the first time by Reliance at Sasan Ultra Mega power project.

The centralized bar bending yard has fully automatic CNC based machines for cutting and bending of reinforcement bars. Material wastage was minimum using optimization software. The CBBY required minimum number of labors. It has centralized inventory. Consistent quality was achieved.

IV. Diagnostic Approach For Setup

A. Rebar Requiement at SUMPP

The total reinforcement tonnage processing required for the project was estimated on yearly and monthly consumption basis as shown in Fig.8. The total requirement was estimated for this project was 70,000 MT having a monthly peak of 3,500 MT

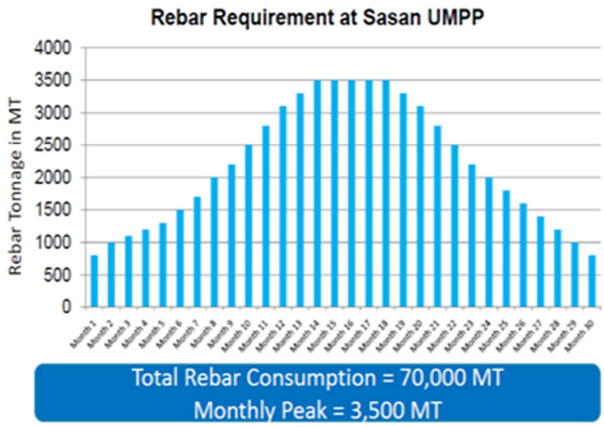


Fig. 8. Rebar requirement at SUMPP

TABLE- II Diameter wiser rebar distribution [1]

S.No	***Diameter of rebar***	***Percentage***
1	8 mm	16%
2	10 mm	11%
3	12 mm	12%
5	16 mm	17%
	Subtotal (Coils upto 16mm dia)	**56%**
6	20mm	16%
7	25mm	13%
8	28mm	4%
9	32mm	8%
10	36mm	5%
	Subtotal (Straight bars upto 36mm dia)	**44%**

It can be seen that more than 50% of the requirement can be met with coil form Rebars.

B. *Selection of Machines for CBBY*

Following parameters were considered in selection of machines for CBBY at Sasan UMPP

- The monthly processing capacity of the yard fixed as 3,000 MT/month/shift.
- National and international markets were surveyed for CNC based reinforcement bar processing machines.
- Machine type and number were decided based on the monthly requirement of reinforcement bars of various diameters.
- Best of class machines were imported based on the processing capabilities
- Special machines were procured for coiled reinforcement bar processing and stirrup making to minimize wastage.

C. *Machines at CBBY at Sasan UMPP*

Various machines in CBBY at Sasan and their capacity in Tons per shift (8 working hours) are given below.

TABLE III. MACHINES AT CBBY SUMPP [8]

S.No.	Machine	Quantity (Nos)	Tons/Shift
1	Focus 12	2	5
2	Mini Syntax	1	10
3	LTM-300	1	40
4	CS-40	1	40
5	CROPPER	2	4
6	IP 42	3	4
7	CAL 55	1	4

All the above machines have a combined capacity of 120 MT/ Shift/ Day. Total capacity in one month assuming one shift per day and 25 working days is 3000 MT (120x25 = 3000)

D. *Machines for Straigh bars*

Shear liner (LTM-300) is used to cut straight re-bars having diameter more than 16 mm to required length as per bar bending schedule .

Fig. 9. Shear liner LTM-300.

Fig.10 . Double bender CS-40

Double bender (CS-40) is used for bending straight re-bars processed from shear liner (LTM-300) to any required shape in 2-dimensional axis. This is a semi automatic machine which is capable of processing the pre-fed shape simultaneously from both ends of re-bar.

E. *Machines for Coil form rebars*

One Mini Syntax has been installed at CBBY in Sasan UMPP for processing coil form re-bars of 6 mm to 16mm diameter to required shape and size.

Two Focus-12 machines were installed for making stirrups from coil form re-bars. Using Focus-12 and Mini Syntax wastage of rebar is almost nil.

Fig. 11. Focus -12 at CBBY

Fig.12. Mini Syntax at CBBY

Fig.13 CBBY shed at Sasan UMPP outside view

Fig.14 CBBY in operation at SUMPP (Inside view)

F. *Methodology for Deployement*

A shed of 2200 SQM (100m x 22m) was built for setting up all machines. The machines were arranged in an orderly pattern suiting the flow of production.

The shed provides an all weather working environment and bar bending can be done irrespective of seasonal effects. All the machines were arranged in an orderly pattern suiting the flow of production.

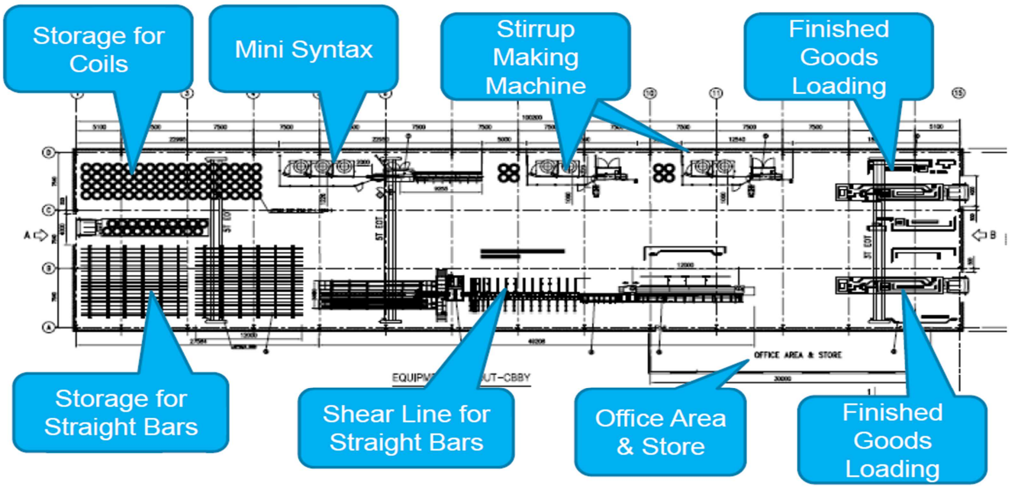


Fig.15 Arrangement of various machines inside CBBY

G. *Central Bar Bending Yard Layout*

A dedicated weigh bridge, well connected road network, concrete hard faced yard for material storage and covered shed for machines were established for central bar bending yard.

H. *Setting up CBBY*

The total CBBY setup was completed in 7 months. Several measures were taken to reduce the setting up time and cost of central bar bending yard. A prefabricated steel building was used. Multiple agencies were deployed parallel to reduce the time of construction.

A dedicated team was monitoring the construction activities through daily Management Information System (MIS) which resulted in not having any delay in construction.

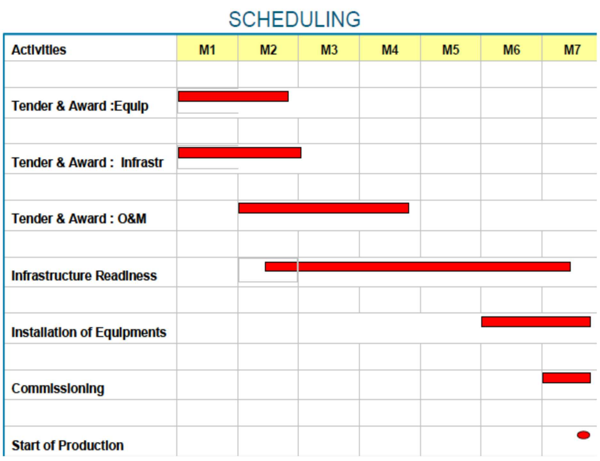


Fig. 14. Schedule in setting up CBBY.

I. *Salient feature of CBBY*

Apart from CNC based computerized machines other salient feature of CBBY at Sasan UMPP are as follows

- Electric overhead travelling cranes for material lifting
- Proper stacking strands
- Hard Faced storage yard
- Dedicated weigh bridge

Fig.16. Salient Features and Layout of CBBY

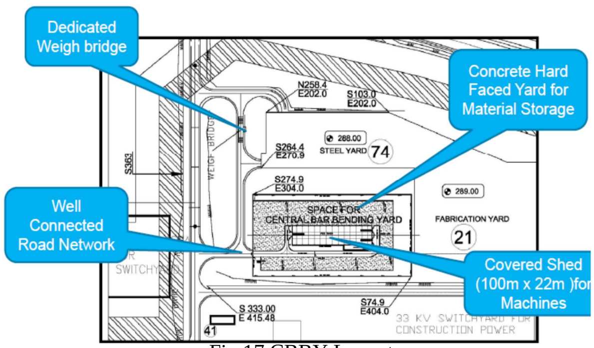


Fig.17 CBBY Layout

J. Modus operandi

- Digital bar bending schedules (BBS) were made from drawings using licensed software.
- Optimization software prepares bar cutting schedules based on fed BBS.
- Precise cutting and bending through CNC based Machines.
- Smart tagging on every bar ensures proper placement and proper delivery.
- A specialist agency was deployed for operation and maintenance of CBBY.

V. BENFITS ASSOCIATED WITH CBBY

A. Quality benefits

Following quality benefits are associated with CBBY.

- Cutting and bending of bars takes place as per codal provisions. Each machine is provided with a set of mandrels having varying diameters to be used with respective size re-bars in conformity with BS 8666 codes [8]
- Unskilled labors involved in bar bending are not educated enough to use suitable mandrel for different diameter of bars. Machines help in achieving variable radius.
- Hard faced yard minimizes reinforcement bar rusting.
- CNC based machines provide precise shapes.
- Smart tagging ensures proper delivery.
- Proper bonding with concrete
- Improved quality of project

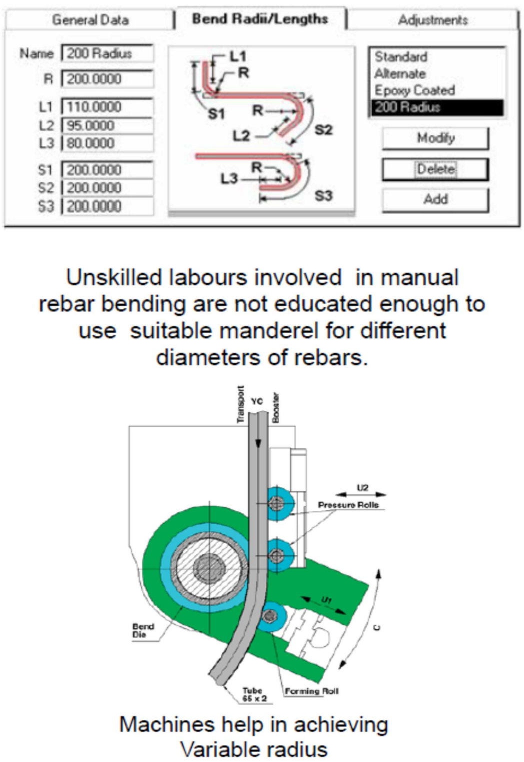


Fig.18. Improper mandrel diameter adds to cracks in reinforcement bars weakening its structural strength

B. Other Benefits

Other benefits associated from CBBY are as follows

- **Minimum scrap generation**- Scrap generated from CBBY is almost nil.
- **Centralized stocking**- Centralized stocking improves control on reinforcement bars.
- **Reduced manpower**- Since Most of bar bending is done by automated machines manpower requirement reduces drastically.
- **Improved record keeping through software**- Software keeps record of all the data
- **All weather working environment**- Bar bending can be done throughout the year irrespective of seasons since all the machines are indoors.
- **Safe working environment**-CBBY has a safe working environment.
- **Ease of supervision**- Supervision of work becomes much easier.
- **Automated billing**- Billing is atomized with the help of software.
- **Weekly and monthly reconciliation** – Exact weekly and monthly reconciliation can be done by software. Reconciliation of materials became much easier.
- **Reduces project cost and time** – Reduction in barb ending time drastically reduces the project duration and project cost.

VI. FINANCIAL BENFITS

A. Savings in CBBY

CBBY has potential savings. Total capital expenses in setting up CBBY are 8 Crores.

TABLE IV Capital costs towards setting up CBBY [1].

S.No.	Work	UOM	Amount
1	Civil works for CBBY	INR	5,830,780.00
2	Material Supply for Shed	INR	8,590,163.00
3	Erection of shed	INR	2,863,388.00
4	Material Supply of EOT cranes	INR	3,377,935.00
5	Erection and commissioning of EOT cranes	INR	154,000.00
6	Electrical material supply	INR	1,728,076.00
7	Electrical installation commissioning	INR	374,078.00
8	Supply, Erection and Commissioning of imported machines	INR	49,160,035.00
9	Supply, Erection and Commissioning of Indigenous machines	INR	2,243,999.00
10	Overheads	INR	5,000,000.00
	Total	**INR**	**79,322,454.00**

Operational expenses for processing 70,000 MT reinforcement bars by deploying a specialist agency including maintenance of all machines along with expenses is 6 Crores

TABLE V Operational costs towards CBBY.

S.No	Description	UOM	Amount
1	Operation charges paid to O&M contractor (At 650 Rs/MT for 70,000 MT)	INR	45,500,000.00
2	Electricity and Miscellaneous expenses	INR	10,000,000.00
3	Overheads	INR	5,000,000.00
	Total	**INR**	**60,500,000.00**

Operation expenses = 6 Crores

Total Expenses = Capital + Operation = **14 Crores**

Cost towards re-bar bending and cutting through conventional methods is **18 Crores**

TABLE VI Cost for processing 1 MT of rebar by conventional method

S.No	Description	UOM	Amount
1	Manpower Bar bender 4 Nos for one day (4x300 = 1200)	INR	1200.00
2	Electricity, Machine depreciation, Machine Maintenance,Handling, etc	INR	800.00
3	Overheads	INR	500.00
	Total	**INR**	**2500.00**

Total Expenses for processing 70,000 MT is 70,000x2500.00 = 175,000,000.00 (Say 18 Crores)

Savings in CBBY = 18 Crores – 14 Crores = 4 Crores.

CBBY has direct potential saving of **4 Crores**

TABLE VII Indirect Savings in CBBY

S.No	Description	UOM	Amount
1	Reduction in wastage @ 2%	INR	5.60 Crores
2	Lower Price of Coil Form@ 3%	INR	3.40 Crores
	Total	**INR**	**9.00 crores**

Indirect saving in CBBY = 9.00 Crores

Total savings in CBBY = Direct + Indirect Savings

= 9.00 + 4.00

= **13.00 Crores**

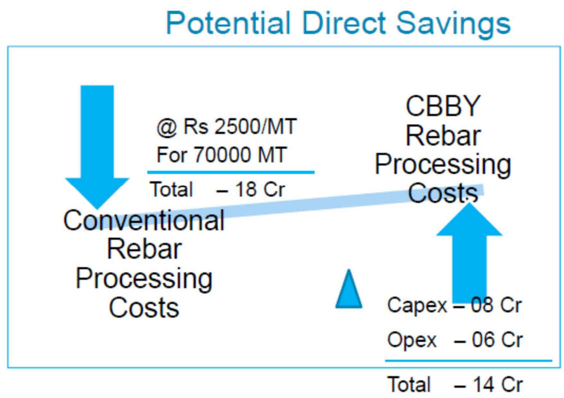
B. Overall Customer Benefits

The overall customer benefits from CBBY can be summarized as follows

- High productivity
- Cost savings – Direct and Indirect
- Improved quality of work
- Reduced Project duration
- Systematic Mechanized working and self reliance

C. Sustainability and way forward

Power plant civil works consists of complex structure of varied sizes and shapes. The uniformity in re-bar processing is very less. CBBY can reduce the time consumption for bar bending to a large extent in this case.



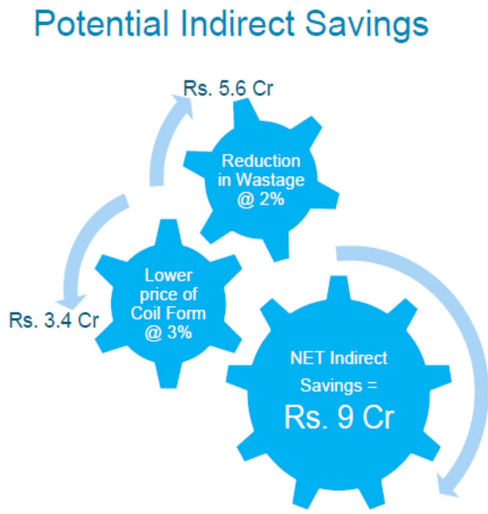


Fig.19. Savings in CBBY

For similar projects of such large scale CBBY can have good financial viability.

The manpower in operation and maintenance can be trained to reduce dependency on third party.

After project completion the machines can be shifted to another project there by reducing the capital expenses in installation of CBBY for next project. The shed and electric overhead cranes to be used as permanent workshop store during operation and maintenance of Sasan Ultra Mega Power Project once the machines are shifted to another location.

CBBY can be implemented successfully for a smaller scale project by reducing number of machines, choosing suitable capacity machines and reducing capital expenses and operational expenses with ensuring required capacity and quality.

The availability of required skilled manpower is becoming a major issue for construction of large projects. CBBY reduces the dependency of large manpower. Using CBBY for bulk steel processing also reduces cost of re-bar processing.

Acknowledgment

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