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Research Article

DEVELOPMENT OF EXPERT SYSTEM FOR THE DESIGN OF FOOD GRAIN STORAGE BIN AND FACILITY

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Abstract- Availability of Safe and adequate storage of food grain ensures sufficient supply throughout a year. An efficient public distribution system depends on suitability of storage structures to handle large quantities with minimum time. Planning of new bulk storage structures along with facilities necessary for handling would be easy and faster with software package. A computer program was developed for designing Reinforced Cement Concrete (RCC) grain bins by using Visual Basic version 6.0 (1998). Programs for designing aeration and conveying system have also been integrated. Output design specifications were validated against worked out specifications for food grain bin. Developed software was informative and user friendly. Present software was found to be valid for the design of RCC silo bin, aeration system and conveying systems for the handling of food grains. Developed computer program will be useful for storage agencies, agricultural engineers and farmers in their decision-making and planning activities.

Keywords- Grain storage, Computer program, Design specifications, RCC grain bins, Visual Basic.

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Introduction

Safe storage of food grains is an important practice after the harvesting of crops in order to ensure food security for long run. The purpose of grain storage is to retain the quality in terms of food value, seed germination and to prevent monetary losses. Total food grain production in India is estimated at 252.68 million tonnes [1]. Around 70 % of total food grains produced is stored at farm level. Majority of food grain losses is result of inadequate and unsafe storage practices at farm level. About 10 % of total production is lost due to inadequate storage [2]. Farmers store their produce in locally made storage structures, which are unsafe and inadequate for safe storage. Farm level grain loses are estimated to be 75% of total loss [3]. The design of storage structures and their construction is an important task in post harvest planning of crops. Time is crucial factor at this stage and requires an expertise to make appropriate decisions about design of storage structures. Design of storage structures and planning would be an easier task with the help of a computer based expert system. An information system was developed in a Canada to create awareness among their farmers and storage agencies. Information used in this system was gathered from the published literature. Developed system could be used to know about important actions and their comparison with others [4]. Flinn *et al.,* (2007) developed stored grain advisor pro to provide insect pest management for wheat stored at commercial grain silos. Developed program can be used for the prediction of future risks. [5].

If a user has first hand and accurate information about structural details and space requirement, one can plan the food grain storage facility accordingly. Present work, the development of expert system for design of food grain storage bin and facility was aimed at development of computer program for planning of RCC bin, aeration and conveying system. Computer program was written in Visual Basic 6.0 (1998).

Materials and Methods

The present work was carried out in the Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, CCS HAU, Hisar in the year of 2013-2014.

Design of RCC bin

Computer program written in Visual Basic 6.0 (1998) was based on the design of RCC bin [6]. Three crops namely wheat, rice and maize were considered for working out the design of RCC bin. The first step in designing RCC bin was to determine height to diameter ratio for given capacity of storage bin. The procedure used was followed as per reported by Mishra [6].

Programming codes were written to select appropriate height to diameter ratio and to determine diameter and height of the bin. Codes for other specifications such as height of hopper (m), hopper opening diameter (m), hopper thickness (cm), Depth and width of top ring beam (cm), Depth and width of bottom ring beam (cm), thickness of cylindrical wall (cm) were written in the Visual Basic 6.0. (1998)

Design of aeration system

Software interface for the design of aeration system was integrated into output interface of bin design. Program coding was performed to work out the design aeration system for RCC bin of given capacity of storage bin.

Selection of airflow rate (m^3/min-tonne)

Airflow rates for wheat and maize were 0.05, 0.09, 0.23, 0.45, 0.68, 0.9, 1.13, 1.35 and 1.8. m^3/min-tonne [7]and that for rice were 0.07 , 0.14 and 0.28 m^3/min-tonne [8]. Selection of appropriate air flow rate is an essential step in designing blower horse power.

Static pressure requirement (inches of water)

Static pressure in inches of water was required to find out the power requirement to operate the system. Therefore values of static pressure were made available in software interface [7][8].

Cross sectional area of duct system(m^2)

Total air volume required was obtained by multiplying air flow rate and volumetric capacity of RCC bin. Cross sectional area of duct system was determined by considering maximum air velocity as 10 m/ sec [8].

$$\text{Cross sectional area of duct} = \frac{\text{Total air volume}}{\text{Air velocity}}$$

Perforated area of duct system(m^2)

Air velocity through granular space was considered to be 0.15 m/sec for obtaining perforated area of duct system [8].

$$\text{Perforated area of duct system} = \frac{\text{Total air volume}}{\text{Air velocity through granular space}}$$

Roof vent area (m^2)

Proportion of vent area for roof was considered to be 2 % of perforated area of duct system[9].

Power requirement (hp)

Power requirement for aeration fan to be operated was obtained by following equation,

$$\text{horse power} = \frac{\text{Total air volume} \times \text{Static pressure}}{63.46 \times 85}$$

Design of bucket elevator

Design procedure reported by Phirake [10] was referred for writing programming codes. Two input parameters *viz*. required capacity of bucket elevator (tonnes/ hour) and speed of elevator (m/sec) were considered for obtaining output design specifications. Software interfaces were designed to display the elevator specifications such as diameter of pulleys (m), capacity of buckets (g), spacing of buckets on belt (m), width of belt (m) and that of bucket (cm), height of elevator and power requirement to operate an elevator.

Design of belt conveyor

For obtaining design specifications of belt conveyor, three input parameters were taken in to consideration namely required capacity of conveyor (tonnes/ hour), conveying distance (m) and inclination of conveyor (degrees). Design procedure reported by Phirake [10] was referred and output interface was designed and coded for finding out specifications of conveyor such as speed of conveyor, width of belt, number of plies of belt, toughing angle, spacing of supporting rollers on carrying and return run, diameter of drive and return pulleys, diameter of supporting rollers and power requirement to operate the conveyor.

Development of software

An integrated development environment of Visual Basic 6.0 provided an appropriate platform for programming. User interface for accepting inputs from user was designed in design mode of Visual Basic and simultaneously codes were written in code window. While designing interface windows, convenience of user was considered and made them more user friendly. Before writing codes for design procedures, all procedures were short coded. Various controls were placed into windows for resetting inputs and printing outputs. After coding and interface design, program was executed for test run. In case of wrong outputs and bugs in program, codes were again edited unless and until desired outputs and errorless execution was achieved as shown in [Fig-1].

Result and Discussion

Execution of the program

Computer program, after execution displayed several interface windows. These appeared interface windows acted as a medium of information between user and computer program. Following sections describes the different interfaces of the program which were designed in Visual Basic 6.0.

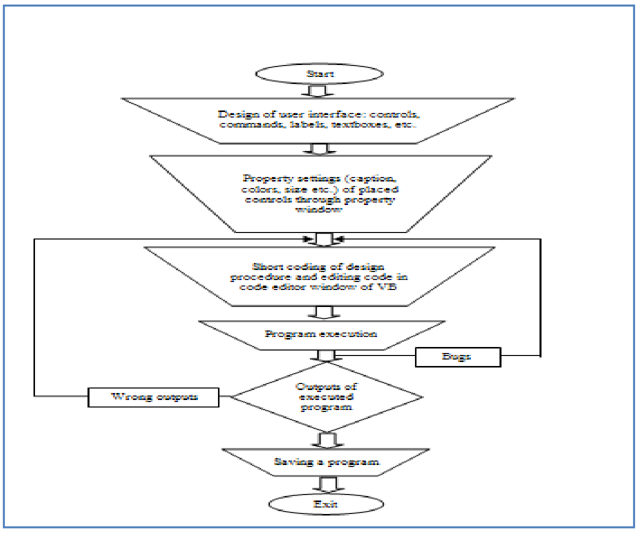

Fig-1 Development of software in Visual Basic 6.0

Input interface for design of RCC bin

An input interface for accepting user's entry appeared after starting the application as shown in [Fig-2]. This window demanded for two input parameter to work out the design of RCC bin. First white bar, where entry was restricted to numeric only, meant for required storage capacity in tonne. For second input, kind of crop to be stored was selected from three options made available. Here, user might have forgotten his entries which in turns would cause the program errors. Therefore, dialogue boxes, as shown in [Fig-3] and [Fig-4], which suggested user their missing entries were associated with command button "SHOW SPECIFICATIONS".

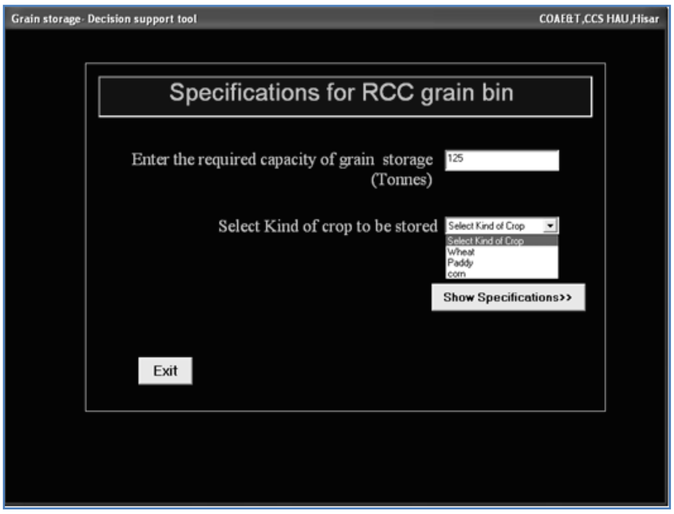

Fig-2 Input interface for the design RCC bin

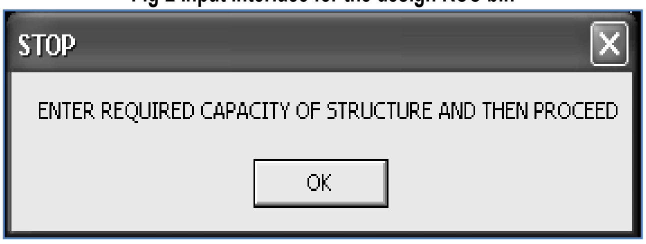

Fig-3 Dialogue box1 associated with command "SHOW SPECIFICATIONS"

Output interface for design of RCC bin

Outputs for the design of RCC bin were generated in two interface windows. Command buttons “Continue” and “Previous” were provided in case of multiple output interface windows. Command button “Reset” was provided to change the input on first interface of outputs. Output interface-1 displayed specifications of RCC bin as shown in [Fig-5].

Output interface-2 displayed design specifications as shown in [Fig-6]. Command button “Print specifications” was provided to take a print out of generated outputs. For designing aeration system and conveying systems command buttons captioned “Aeration”, “Bucket elevator” and “Belt conveyor” were provided on this interface.

Fig-4 Dialogue box2 associated with command button “SHOW SPECIFICATIONS”

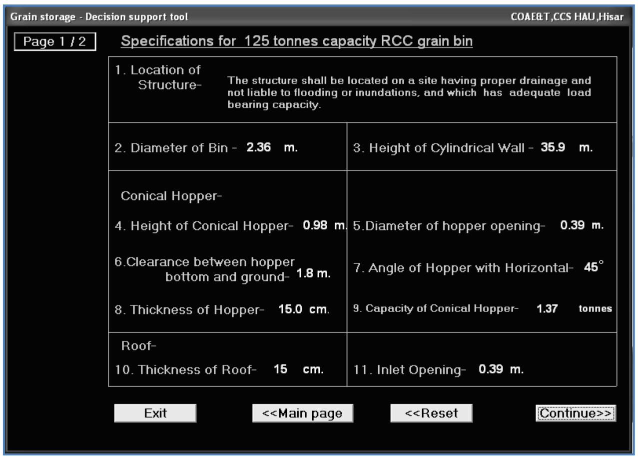

Fig-5 Output interface-1 for the design of RCC bin

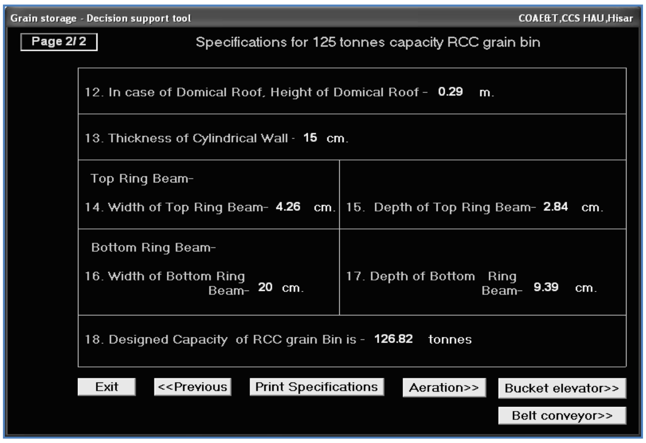

Fig-6 Output interface-2 for the design of RCC bin

Input interface for design of aeration system

Aeration system was designed for given capacity of RCC bin. Input parameters for design of aeration system were decided after studying available design procedure. Design of fan horse power, cross sectional area and perforated area of duct system were dependent upon desired airflow rate and static pressure requirement. Experimental values of static pressure for different airflow rate were available [7] [8]. Therefore, first input entry required for design of aeration system was airflow rate (m^3/min-tonne) and second was static pressure in inches of water. A command button “Click here for details of static pressure” was made available to view chart of static pressure for different air flow. Design specifications of aeration system were displayed on output interface as shown in [Fig-8].

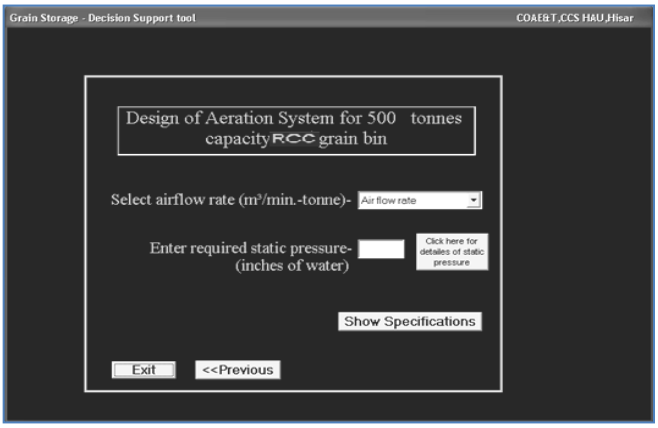

Fig-7 Input interface for design of aeration system

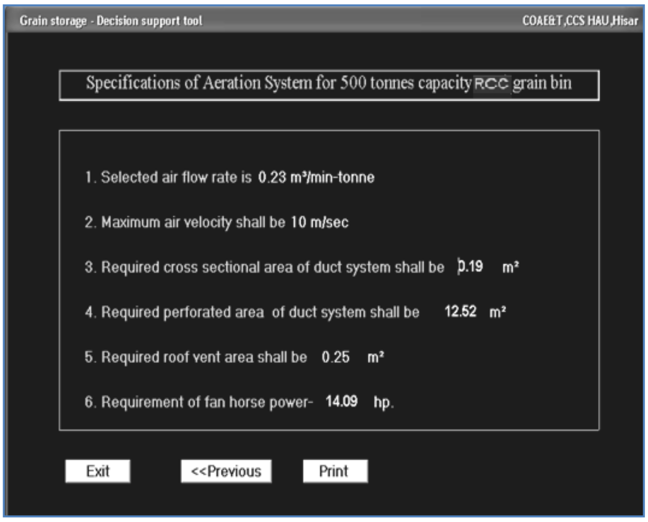

Fig-8 Output interface for design of aeration system

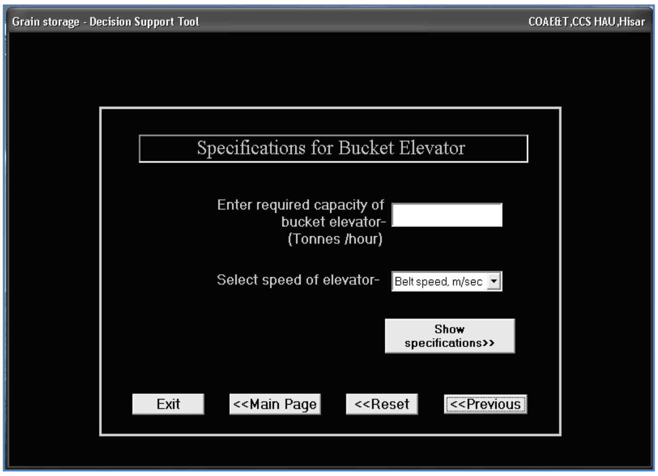

Fig-9 Input interface for design of bucket elevator

Input interface for design of bucket elevator

As per available design procedure for bucket elevator, design of horse power, diameter of drive pulley, width of belt, bucket spacing and width of bucket was dependent on required capacity (tonnes/hour) and speed (m/sec) of elevator. Theoretical recommended speed of elevator is between 2 to 4 m/sec [8]; therefore options for selecting speed were 2, 2.5, 3, 3.5 and 4 m/sec. Input interface for elevator design was appeared as shown in [Fig-9]. Computerized specifications of bucket elevator were as shown in [Fig-10].

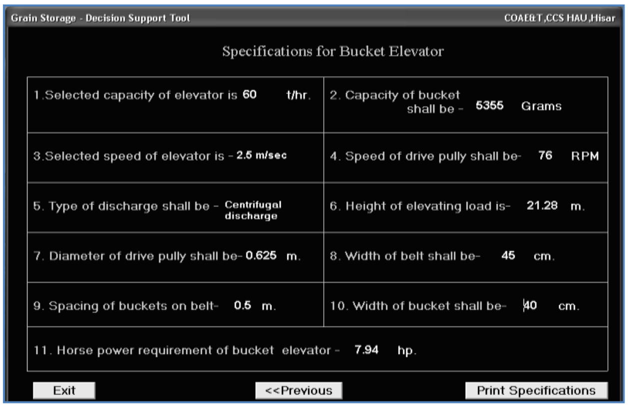

Fig-10 Output interface for design of bucket elevator

Input interface for the design of belt conveyor

Required input parameters for designing belt conveying system were desired capacity of conveyor (tonnes/hour), conveying distance (meters) and angle at which belt is to be inclined in degree. Input interface for conveyor design was appeared as shown in [Fig-11]. Design specifications displayed for belt conveyor of given capacity were as shown in [Fig-12].

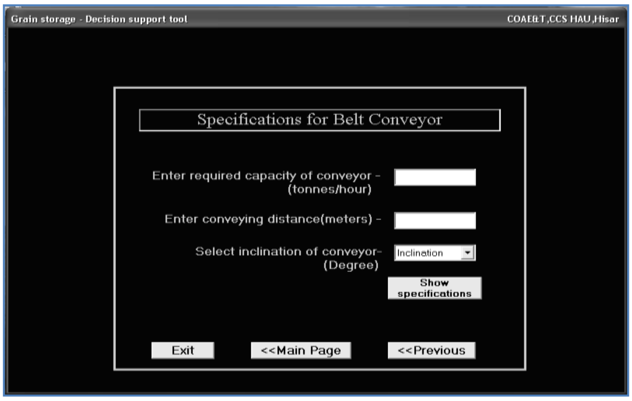

Fig-11 Input interface for design of belt conveyor

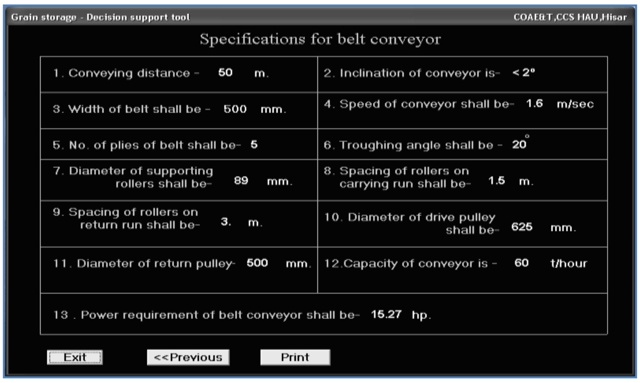

Fig-12 Output interface for design of belt conveyor

Validation of Computer Program for Design of RCC bins

Developed software was tested for different capacities of RCC bins. Input capacities for trial were selected on the basis of availability of existing specifications for these capacities. Computerized design of RCC bin for capacities 50, 100, 500, 1000, 2000, 3000, 4000 and 5000 was similar to those reported by Mishra [6] as shown in [Table-1] and [Table-2].

Computerized designs for bucket elevator and belt conveyor were also validated for capacities 10 and 60 tonnes/hour respectively. Computerized power requirement for elevator and belt conveyor was 1 and 15.5 hp respectively. Similar power requirement for given conveying system was reported by Phirake [7] as shown in [Table-3] and [Table-4].

Conclusion

Design specifications of RCC bins were dependent on storage capacity and type of crop to be stored. Design of bucket elevator was dependent on their capacity, belt speed and height of elevator, whereas design of belt conveyor was dependant on required capacity of storage bin, conveying distance and inclination of conveyor for handling of food grains. Developed computer program was more informative for the design of storage bin and conveying system. Validation of computer program was found to be comparable with manually worked out design of RCC bin. The developed software will be highly useful for storage agencies, agricultural engineers and farmers for planning of emergency storage structure at farm level in order to ensure safe storage of their produce.

Table-1 *Validation of computerized design of RCC bin*

	50 tonnes		100 tonnes		500 tonnes		1000 tonnes	
	Manual	Computerized	Manual	Computerized	Manual	Computerized	Manual	Computerized
H/D Ratio	15.00	15.00	15.00	15.00	13.50	13.60	10.50	10.50
Diameter of bin(m)	1.74	1.74	2.19	2.19	3.88	3.88	5.30	5.30
Height of bin (m)	26.10	26.6	32.80	33.35	52.30	52.88	55.70	56.15
Thickness of roof (cm)	16.00	15.00	16.00	15.00	16.00	15.00	16.00	15.00
Top ring beam, D(cm)	2.09	2.09	2.63	2.63	4.66	4.66	6.38	6.38
Top ring beam, W (cm)	3.14	3.14	3.95	3.95	6.99	6.99	9.57	9.57
Thickness of bin wall (cm)	15.00	15.00	15.00	15.00	15.00	17.00	15.00	17.00
Bottom ring beam, D (cm)	5.18	5.18	8.11	8.11	24.65	24.65	36.31	36.31
Bottom ring beam, W (cm)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Thickness of hopper (cm)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

Table-2 *Validation of computerized design of RCC bin*

	2000 tonnes		3000 tonnes		4000 tonnes		5000 tonnes	
	Manual	Computerized	Manual	Computerized	Manual	Computerized	Manual	Computerized
Height to dia. Ratio	8.00	8.06	7.00	7.05	8.00	8.05	8.50	8.55
Diameter of bin(m)	7.30	7.30	8.73	8.73	9.20	9.20	9.72	9.72
Height of bin (m)	58.40	58.9	61.10	61.61	73.6	74.1	82.6	83.12
Thickness of roof (cm)	16.00	15.00	16.00	15.00	16.00	15.00	16.00	15.00
Depth, top ring beam (cm)	8.79	8.79	10.50	10.51	11.00	11.07	11.70	11.69
Width, top ring beam (cm)	13.20	13.18	15.80	15.76	16.60	16.61	17.50	17.54
Thickness of bin wall (cm)	16.10	17.00	17.30	19.00	22.70	27.00	28.10	33.00
Depth, bottom beam (cm)	54.98	54.98	72.92	72.92	106.3	106.3	136.53	136.53
Width, bottom beam (cm)	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Thickness of hopper (cm)	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00

Table-3 *Validation of designed bucket elevator*

	Manual	Computerized
Capacity of bucket elevator (tonnes / hour)	10	10
Height of elevator (m)	8.6	11.62
Speed of elevator (m/sec)	2	2
Type of discharge	Centrifugal	Centrifugal
Diameter of drive pulley (m)	0.4	0.5
Speed of drive pulley (RPM)	95	76
Bucket capacity (grams)	480	1105
Spacing of buckets on belt (m)	0.32	0.4
Width of bucket (cm)	16	20
Width of belt (cm)	20	25
Required horse power (hp)	1	1

Table-4 *Validation of design of belt conveyor*

	Manual	Computerized
Capacity of belt conveyor (tonnes / hour)	60	60
Conveying distance (m)	57.5	58
Inclination of belt conveyor (degree)	-	< 2
Toughing angle of belt (degree)	20	20
Speed of conveyor (m/sec)	1.6	1.6
Width of belt (mm)	500	500
No. of ply in belt	4	5
Diameter of drive pulley (mm)	500	625
Diameter of return pulley (mm)	400	500
Diameter of supporting roller (mm)	89	89
Spacing of roller on carrying run (m)	1.4	1.5
Spacing of roller on return run (m)	3.0	3.0
Power requirement (hp)	15	15.5

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Author contributions

The present study was conducted by first author in partial fulfillment for post graduate degree programme, under the guidance of second author in the Department of Processing and Food Engineering, CCS HAU, Hisar.

Abbreviations

RCC: Reinforced Cement Concrete
m: meter
cm: centimeter
sec: seconds
g: gram
min: minute

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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