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Silos Engineering

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Abstract:

Storage silos are cylindrical shape structures with the slip and straight form. Concrete silos are the larger in terms of diameter and height . Silos could be made of many materials. Wood , concrete , cast concrete, and steel Plates ,corrugated sheets glass lined steel bolted type etc. These vary according to cost durability. Silos storing grain, cement and chemical Powders are typically unloaded with air slides. Silos can be unloaded into rail cars, trucks or conveyors.

This paper means metal silos for wheat.

Since these types of projects include multiple engineering disciplines as a component of their technical and operational elements, and require early technical studies, which cannot be fully presented through this research paper. Therefore, the project life cycle has been exposed, starting from the stage of feasibility study - value engineering - risk assessment - timetable - Technical requirements for all disciplines (mechanics - civil works - electricity).

Here presenting what we saw appropriate in this context and remains details that may have the opportunity to shed light on them later

Keyword : Silos, Engineering,Storage

1.1 Research problem

Therefore, with the expansion of the construction of silos, especially metal ones, which can accommodate huge quantities of wheat for long periods, they must be preserved from damage, in addition to the dynamic filling and emptying operations, which cause varying loads on the structural elements of the silo and Dust explosion problems. Therefore, the research addresses these factors and develops frameworks to maximize benefits and reduce costs and risks.

1.2 Target

Understanding the behavior of the facility during the operation phase

Choose the optimal design Environmental factors affecting wheat stocks

Establish implementation methods to link the various engineering departments in a way that does not affect time frames or costs And quality

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Formulating recommendations that contribute to avoiding harmful factors, whether related to engineering, storage or environmental aspects

Enriching silo engineering with what must be taken into account throughout the project life cycle, starting with feasibility studies

1.3 The importance of Research

Establishing grain silos that achieve their goal throughout their lifespan Highlight influencing factors Design relationships to operating processes and situations

1.4 Research limits

Geography: outside and inside Egypt from a theoretical standpoint and inside Egypt from a practical standpoint Chronologically: from the nineteenth century until today

2 Introduction

The human needs for seeds, especially wheat, have accompanied a rapid development in the storage industry.

The construction and operation of smart storage units comes as one of the pillars of this development. Engineers and specialized companies are working to provide the best means and solutions for storing and circulating wheat in accordance with industrial and health requirements. Together, from here, wheat stores have become a place Great interest and care for broad sectors. This research paper is an open window on this important branch in the construction sector linked directly to citizens and their living needs.

In his study, the researcher relied on important references, the results of his participation in the design and construction of many silo projects, and laboratory experiments.

Since it is not possible for the current research to cover all the technical aspects in detail, it was taken into account to focus on the design requirements, components, and requirements. As for the theoretical studies, we will go over them, and special research can be devoted to them later

3 Predesign stage

3.1 Feasibility Studies

A legal,financial,,marketing and technical feasibility study is being carried out, and we summarize here the important elements taken into considerations of the technical feasibility study.:

- Introduction

o Domestic wheat production o Wheat trade and storage o Imports o In-land storage

o Wheat value chain o Conclusion

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- Statistics
- Project description
- Drawings

o Silo configuration o Descriptive drawings o Flow diagram o Survey works
o Assign the proposed design in locations

- Time schedule- Wheat Storage Methods- Final target- Duration and work plan
- Implementation modalities- Project Structure- Procurements- Resolutions
- Budget- Financial indicators- Institutional sustainability- Socio-cultural sustainability

3.2 Risk Management

Studying, evaluating and managing risks is one of the main axes to identify risks, the probability of their occurrence and their effects, and to develop the necessary plans to prevent them or limit their effects according to each case and in order to do so.

The analysis and management of risks in the project is a continuous process that can start at any stage of the project life cycle and can last and continue, whose costs become greater than its potential benefit, and as the project progresses, the risks decrease. Silos, as there are risks associated with the life of the project, so it is recommended to use them in the early stages of the project life cycle. Consider the following for guidance:-

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3.2.1 Definition:

3.2.1.1 Risk is an un-certainty that matter, it can affect project objectives negatively or positively

3.2.1.2 or

3.2.1.3 The effect of un certainty on objectives (ISO 31000-2009)

1.1.1.1 *Example For Silos Projects: Dust explosion, Rust and High temperature*

3.2.1.4 -Project objectives

3.2.1.4.1 Silos Project must be delivered within cost. On time. Scope and must meet customer quality requirement

3.2.2 Risk types

3.2.2.1 Negative: Threat – bad

3.2.2.2 Positive: Opportunity- good

3.2.2.3 <u>Success factors for the identify risks processes (PMI)</u>

3.2.2.3.1 Early identifications: Risk identification should be as early as possible in the project life cycle

3.2.2.3.2 Iterative identification: Risk identification is repeated throughout the project life cycle

3.2.2.3.3 Emergent identification: Risk identification at any time not limited to formal Risk identification events or regular reviews

3.2.2.3.4 Explicit identification of opportunities: Risk identification process should ensure opportunities

3.2.3 <u>Data </u>Gathering<u> </u>:

3.2.3.1 Brainstorming:

3.2.3.2 Check lists:

Are quick to use Provide useful guide for the projects . That are standard or routine in nature (May be suitable for Silos projects).

But when check lists can be valuable for routine activities, they can be a major handcip For non standard or unique projects

When the project is not as the same as any thing the organization has dealt with before, then a check list can provide a constraint on creative through and blocking the identification of risks that go beyond those in the list.

3.2.4 Risk break down structure (RBS)

- RBS is hierarchical representation of potential source risks
- RBS can be useful when identifying or when categorizing identified risks
- RBS supports the team in better understanding of involved risks

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Example : Risk break down structure

category	ID		Risk factor	
Environmental	R1	E1	Nature factors(flood-earthquakes-and so on) Effect of temperatures and harmful organisms on wheat	
& location	R2	E2	Distance- Services surrounding the silos - location in relation to agricultural fields	
Design	R3	D1	Design team experience	
and	R4	D3	Confusing requirements	
construction	R5	D 4	Design modifications	
	R6	C1	Not available workers, materials or equipment	
	R7	C2	Poor communication between he consultant team and	
Financial	R8	F1	Labor cost is higher than predicted	
	R9	F2	Inflation	
	R1 0	F3	Delay payments of completed works	

3.2.5 Risk Register

The main output from the identify risks process is the risk register

Includes a properly structured risk description and the nominated risk owner to each risk

Also includes the cause and effects of the risk tigger,condtions and preliminary responses(PMI Practice standard)

It provide a mechanism for maintaining awareness of the number and type of risks

The risk register records details of all risks identified throughout the project life cycle

Example: Risk Register

ID	risk name	threat/opportunity		Risk owner
Technical				
-				
scope		threat		
A1000	As a result of in complete scope there is a risk that scope changes may arise during project causing project delay			
design		threat		
A1010	As a result of lack of coordination in drawings there is a			

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	risk conflict in construction may effect time/cost			
compexibiity				
A1020	As a result of complexity project design there a risk deign modifications may arise may effect time/cost	threat		
quality				
safety				
Managment				

3.2.6 Risk Assessment

3.2.6.1 Probability

3.2.6.2 Impact

3.2.6.3 Risk Matrix

Probability	RISK SCORE /TIME					RISK SCORE /COST					
V.HIGH											
HIGH											
MEDIUM											
LOW											
VERY LOW											
	VERY low	LOW	MED	HIGH	V.HIGH	VERY low	LOW	MED	HIGH	V.HIGH	
		IMPACT					IMPACT				

3.2.7 Plan Risk Responses

The process of developing options, selecting strategies, and agreeing on action to treat individual

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3.2.8 . Design Stage

3.2.9 Codes

3.2.10 Introduction

The structural design of flat-bottom circular silos containing grain-like material represents a challenging issue. The complex mechanism through which the ensiled material interacts with the silo wall is under study from almost two centuries, many uncertainties remain, and structural failures still occur. A brief overview about different silo failures and structural consequences during filling

3.2.11 History of silo codes

Various attempts have been made over the last 50 years to codify solids-induced pressures acting on silo walls. The first code to provide helpful rules to design engineers calculating silo loads was developed from the extensive testing performed by Pieper and his colleagues [2], who produced the German Standard DIN 1055 Part 6 "Design loads for buildings: Loads in silo bins". This standard, which was first published in 1964, has been significantly revised and reissued twice -- 1987 and 2005. Other groups in other countries have codified solids-induced silo wall pressures, and this process continues today. Various terms are used to describe these documents: Standard, Code, Guidelines, Recommended Practice, Engineering Practice, etc. Documents titled "Code" or "Standard" require compliance, whereas those titled "Recommended Practice", "Guidelines" or "Engineering Practice" might be considered recommendations only, not requiring mandatory compliance. While that may be true in a strict legal sense, this does not absolve an engineer from responsibility for what should be his/her primary focus: safety, regardless of pressure that may come from clients or others. Safety, and then economy, must determine the design. For practical purposes, "Guidelines", "Recommended Practices" and "Engineering Practices" should be considered minimum mandatory standards. In other words, an engineer has the right to exercise independent engineering judgment when creating a design, and he/she may even go back to first principles. However, if a problem occurs and the engineer is required to justify the design, there will be a very strong presumption against the engineer that is very difficult to overcome in most cases if the engineer has not at least considered all applicable "Guidelines", "Recommended Practices" and "Engineering Practices".

The first Australian publication on solids-induced pressures on silo walls was titled "Guidelines for the assessment of loads on bulk solids containers". It was published in 1986 by a working party on bins and silos of the Australian Institution of Engineers' National Committee of Structural Engineering. This was followed by Australian Standard AS 3774, which was first published in 1990 and then revised in 1996. [10] This standard can be considered one of the precursors of EN 1991-4:2006, since Michael Rotter was the lead author of both documents. Unlike EN 1991-4:2006 this standard does not include Action Assessment Classes, but it does include upper and lower characteristic values of key material parameters. It includes four classifications of loads (dead loads, normal service loads, environmental loads and accidental loads) and a table describing load combinations that must be considered. Some often-overlooked conditions such as permissible geometric deviations in silo geometry and effects of wall flexibility are described. Even though it includes methods to calculate wind and seismic loads, this is perhaps best handled using the most up-to-date general design code such as the Universal Building Code (UBC

3.2.12 Cases- Conditions

3.2.12.1 Flow patterns

Only two of these codes (EN 1991-4:2006 and AS 3774-1996) cover the flow pattern call mass flow, which occurs when a silo's hopper walls are sufficiently smooth and steep that all the material is in motion whenever any is withdrawn. Funnel flow occurs with less steep or less smooth hopper walls, which results in some of the material remaining stagnant while the rest (directly over the outlet) is flowing. These four codes use somewhat different terms to describe this flow pattern. EN 1991-4:2006 and AS 3774-1996 use the term mixed flow to describe the condition of the flow channel intersecting the silo wall, whereas ANSI/ASAE EP433 calls this plug flow. EN 1991-4:2006 and AS 3774-1996 use the term pipe flow to describe the condition when the flow channel does not intersect the silo wall. None of these codes covers expanded flow, which is a combination of mass flow and funnel flow.

3.2.12.2 Internals

Structures are often placed within a silo in an attempt to alter the flow pattern, facilitate introduction of a gas into the bulk solid for processing, heating, cooling, etc., reduce pressures on silo walls, or to reduce loads on the outlet region. These structures include so-called Chinese hats, cone-in-cone inserts, and cross beams as shown in Fig. 2. Loads on such internal structures can be extremely high, and many have failed or caused silos to fail. They also alter the pressure distribution on silo walls in the vicinity of the insert. Only AS 3774-1996 addresses loads on such internals, but the calculations are rather simplistic and do not include the effects of internals on the silo wall. EN 1991-4:2006 identifies these problems and requires a rational analysis to be used in addressing them.

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3.2.12.3 Thermal ratcheting

Thermal ratcheting is a condition in which successive temperature cycles cause increasing pressures on metal silo walls. Metals have a higher coefficient of thermal expansion than bulk solids, and metal silo walls react more quickly to ambient temperature changes than the stored bulk solid. Thus metal walls expand with increasing temperature, and the stored material settles (assuming no discharge). When the ambient temperature drops, the walls attempt to contract, but the bulk solid could only be pushed upward to its previous level if the direction of friction in the solid and between the walls and solid were reversed. This causes stresses within the wall to increase significantly [13], and the phenomenon may continue ("ratcheting") with each succeeding temperature cycle. ANSI/ASAE EP433 provides an estimate of this effect on silo walls in 4.4.1, but notes in the Commentary that this estimate is based on laboratory studies using steel model circular silos. It notes that qualitative results collected from full size silos are available in the literature, but that "quantitative results needed for design purposes are not available from large silos". AS 3774-1996 and EN 1991-4:2006 cover this phenomenon much more completely than ANSI/ASAE EP433, while ACI 1997 does not address it at all.

3.2.12.4 Grain swelling

This is a known cause of a number of silo failures. ANSI/ASAE EP433 notes in 4.4.2.1 that "moisture increases during storage of 4% or more can cause lateral pressures to increase several times static load conditions." It notes in the Commentary: 5.4.2 Stored grains are hygroscopic; that is, they absorb moisture from liquid sources and from the atmosphere. When grains absorb moisture, they expand. When grains are confined within a structure, the expansion is restrained. The consequence is an increase in bin wall pressure. It notes that data on this subject in the literature is limited in number and scope, but that some studies have reported that lateral pressures increased by a factor of six as grain moisture increased by 4%, and by a factor of ten for a 10% increase in grain moisture content [13]. AS 3774-1996 also covers this phenomenon, but neither of the other two codes covers it.

3.2.12.5 Effects of gas pressures

Sometimes gas is added to storage vessels to cause or suppress chemical reactions, cool or heat the bulk solid, etc. If sufficient gas is added, a completely fluidized condition develops, and the wall pressures change to essentially hydrostatic. ACI 313-97, EN 1991-4:2006 and AS 3774-1996 provide guidance on this condition.

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3.2.12.6 External equipment

External equipment such as electric or pneumatic vibrators, vibrating bin discharger (bin activator), localized aeration devices, and air cannons impart significant forces to a silo structure that must be taken into account. They can also affect the stored bulk solid in such a way that its properties change, resulting in different silo loads. AS 3774-1996 provides some limited guidance on this phenomenon, but it does not cover loads acting on external equipment itself by the stored bulk solid. The other three silo design codes do not cover this at all. Feeders and gates are also critical to a safe and properly functioning silo. AS 3774-1996 provides guidance regarding loads imposed on them, but the other three codes do not.

3.2.12.7 Buckling phenomena

Metal silos used to store granular solids often take the form of a cylindrical shell with an aspect ratio in the range $2<H/D<6$. It has long been recognized that the most serious load case for all silos is probably the condition of eccentric discharge of its stored solid, but in circular metal silos this is especially true. More failures have occurred under this condition than any other. This high failure rate is chiefly due to the complexity of the pressures exerted by an eccentrically discharging granular material, and the difficulty in understanding the pattern of stresses that develops in a shell wall under such unsymmetrical pressure regimes. The nonsymmetrical behavior of a shell structure under unsymmetrical pressures is not at all well described in the voluminous shell structures literature, and only a few studies have explored the mechanics leading to high local stresses which in turn lead to buckling failure under eccentric discharge.

This study follows an earlier initial exploration by Sadowski and Rotter (2010) [2], in which buckling in a moderately slender perfect silo was explored. Here, the work is taken further to explore a very slender structure, and to investigate the imperfection sensitivity of this failure mode. The pressures caused by eccentric discharge are characterized using the new rules of the European Standard EN 1991-4 (2006) [1] that define the actions in silos and tanks. Using this new improved description of unsymmetrical eccentric discharge pressures, it is now possible to perform relatively realistic calculations relating to this common but complicated shell buckling condition. The shell buckling calculations described here employ a pressure distribution formulated with the assumption of a parallel-sided flow channel and are undertaken using geometrically and materially nonlinear analyses in accordance with the European Standard EN 1993-1-6 (2007) [25] on the strength and stability of shells.

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3.2.12.8 Recommendations

In order to structurally design a silo, an engineer must determine all loads that are likely to be applied to it. These include, among others, wind, seismic, external, and loads induced by the stored bulk solid. Numerous codes and standards specify means to calculate the latter (so-called solids-induced loads). Among them, as:

x British Standard BS EN 1991-4:2006 “Eurocode 1 – Actions on structures – Part 4: Silos and Tanks”

x American Concrete Institute ACI 313-97 “Standard practice for design and construction of concrete silos and stacking tubes for storing granular materials”

x American Society of Agricultural Engineers ANSI/ASAE EP433 DEC1988 (R2011) “Loads exerted by free-flowing grain on bins”

x Australian Standard AS 3774-1996 “Loads on bulk solids containers” Unfortunately, guidance to the user is inconsistent between these codes. In addition, many common silo design conditions are not covered by any of them. A brief description of each of these codes, their limitations, and common design conditions that are not covered are identified. Users of silo codes will find this information invaluable, as will code writers who will benefit by being given direction as to how to improve their codes to make them more useful codes .

3.4 AS 3774-1996 “Loads on bulk solids containers”

3.2.13 Conclusions

Knowledge of the loads applied to the walls and internals (if any) of a silo is extremely important. Such loads must not be ignored if a stable, safe silo is to be designed. Much progress has been made in the last 50 years in providing silo load guidance to design and structural engineers. EN 1991-4:2006 is a significant advance over all previous codes, but even it does not cover many common load cases. For load cases not covered by the codes, the design/structural engineer is left with two choices: x Be extremely conservative in estimating applied loads. This approach can be quite expensive and yet still may not be conservative enough to prevent the silo from failing. x Rely on design engineers who have significant experience in calculating silo

3.3 Value Engineering

3.3.1 The definition :

There are many definitions of value engineering, such as Dell,isola -Zimmerman Hart-Miles definitions .But Here we can take into account the definition of SAVE organization:

It is the organized application of the technique of functional definition of a product or service, determining the value of each function, and achieving the necessary functions at the lowest possible cost.

3.3.2 Value engineering in the design phase

As happened at the beginning of value engineering and its transformation from the reality of implementation to the design stage, it also happened to you in construction projects, and therefore its principles must be applied in silo projects.

The benefits Value engineering is an effective systematic method for solving problems that has proven its feasibility in most developed countries of the world. The reason is that it is possible to identify areas of unnecessary costs and improve quality and performance together as a result of the suggestions and recommendations of a work team consisting of several specializations.

3.3.3 Stages of the value engineering curriculum

3.3.3.1 Collecting information:

The more information there is and is verified, the more effective value engineering becomes. This stage is considered a continuation of the pre-study stage

3.3.3.2 Function phase

3.3.3.3 Creative phase

3.3.3.4 Final evaluation and testing:

Selection criteria are set for the alternatives that have been arranged (using statistical methods) so that each criterion is weighted with a maximum of ten degrees and the criteria that can be applied to projects Compatibility with technology - cost of developing the idea - ease of application - high return - efficiency of functional performance - ease of maintenance - energy saving - formal and aesthetic effect - environmental impact

3.3.3.5 Development phase

3.3.3.6 Reporting phase

3.3.3.7 Presentation phase :

Formulating the proposal that enables the official to make the optimal decision, and the focus must be on the technical and financial aspects

1.1.4 In conclusion,

the application of value engineering in silo projects is an important matter and achieves significant results. This is clearly evident when determining the silos, whether they are horizontal, conical, or warehouses according to their purpose, whether they belong to ports, field or main silos, and other factors involved in the evaluation, and whenever the study is in the stage The earlier the design, the more effective and realistic the results - see diagrams

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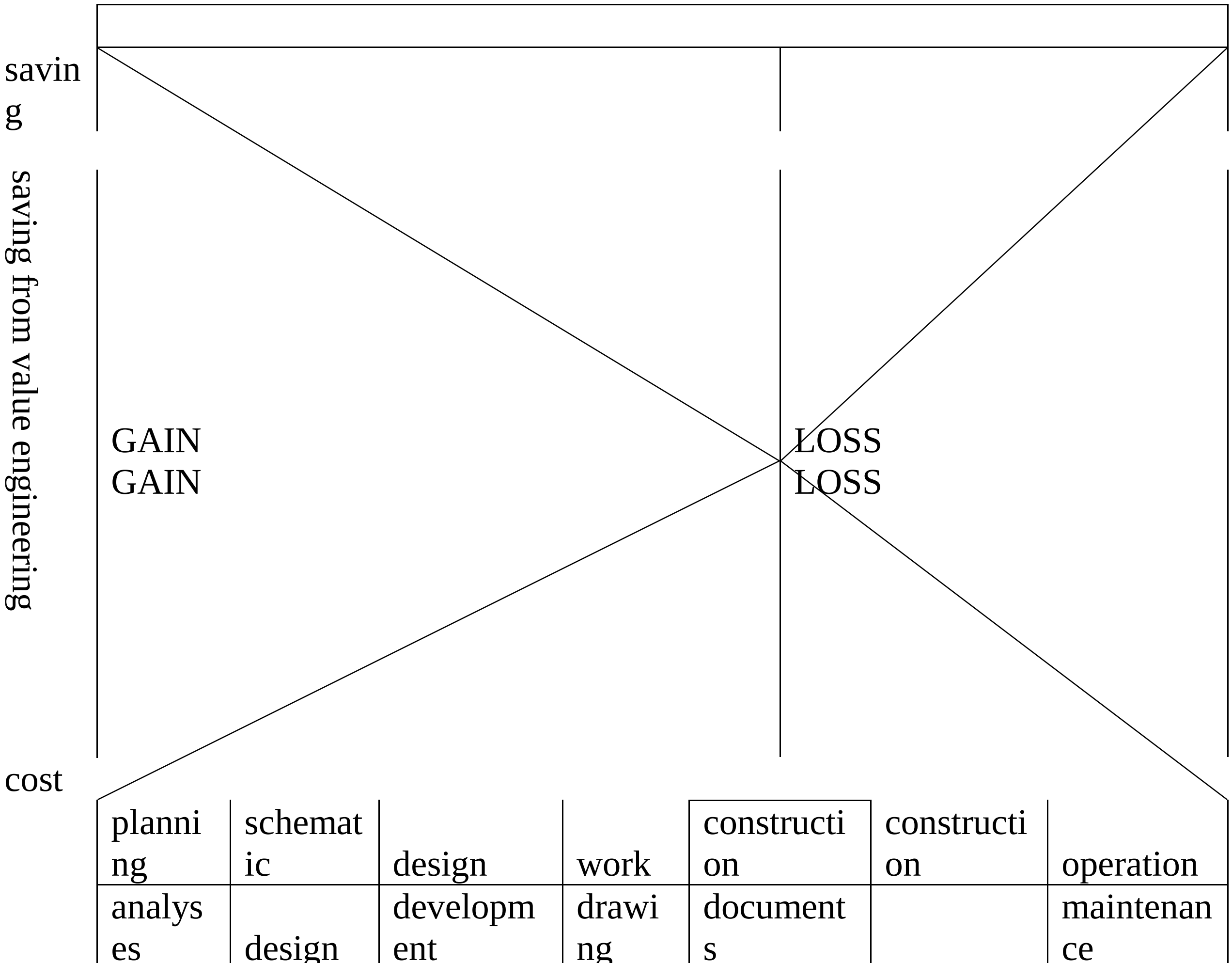
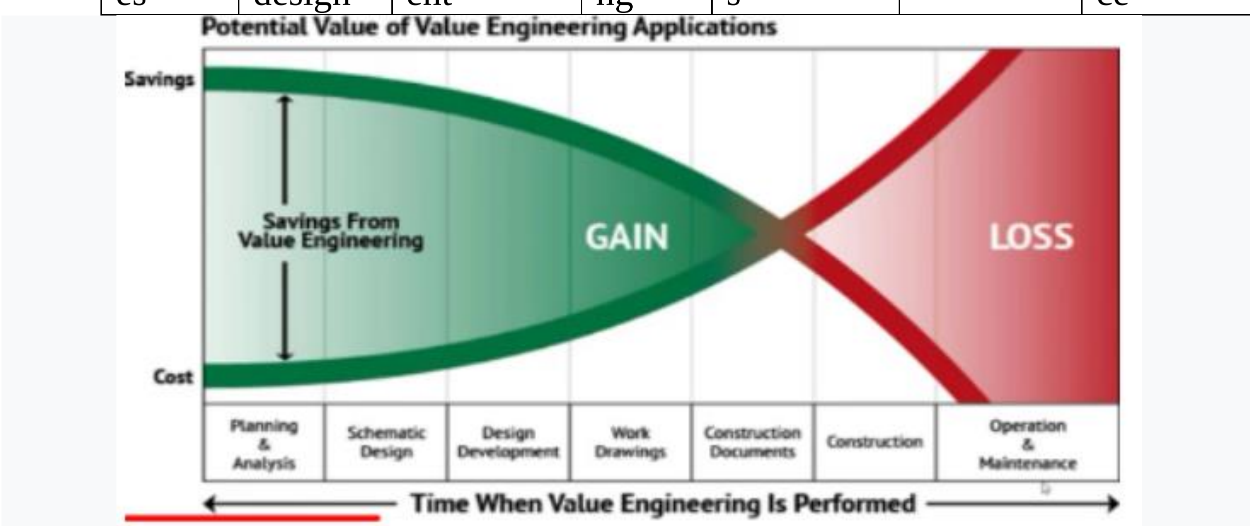
Importance of value engineering during project





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3.4 Loads &Requirements and Conditions

3.4.1 Technical Data:

3.4.1.1 -Data of grain to be stored:

3.4.1.1.1 Wheat:

-Density: 740-900 kg/m3

Max. Moisture content: 13.5 for imported wheat
13% for local wheat

--Purity: 96% for imported wheat
92% for local wheat

-Angle of repose: 28°-30° for imported wheat
38° for local wheat

- All storage Silos, delivery bins, conveyors and elevators and their supporting structures shall be designed according to the following parameters:

- Wind load: Wind velocity must be calculated According to the approved code or specifications for the project
- Dynamic load: Resulting from continuous filling & emptying at the given capacities, due to vibration of conveyors, elevators, gearboxes, motors etc.….
- Earthquake loads: Earthquake loads shall be According to the approved code or
- Thermal expansion So as to allow the remainder of any equipment to move as would be required by thermal expansion coefficient over the ambient temperature range specified.

3.4.1.2 Temperature &Humidity

-Ambient Temperature and Humidity: Ranges between + 1 °C and 50 °C

-Relative humidity: Ranges between 50% -100%

3.4.1.3 Electric Power Supply

-Electric Power Supply: 3 Phase 380 / 220 ± 10% volt
4 wire, 50 Hz ± 2%

3.4.1.4 -Grain Dryer Criteria:

a) Wheat: Input Humidity 16% Output Humidity 13%

b) Maize Input Humidity 18% Output Humidity 14%

c) Rice Input Humidity 18% Output Humidity 14%

Dryer shall have all equipment needed such as temporary storage silo, bucket elevator, conveyors, any other accessories and civil works.

Dryer fuel shall be Diesel; monthly underground fuel tank shall be included.

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3.4.2 General Technical Requirements:

- Here we provide some requirements as a guide, and the details are prepared by the stakeholders and project specialists according to studies, operation and maintenance needs, and value engineering outputs

3.4.2.1 Equipment's

3.4.2.1.1 Choosing

- All conveyors & elevators shall be electrically driven and designed for continuous industrial duty and to be operated in an outdoor environment. Operation is estimated at up to 20 hours per day.
- Equipment or parts which will be subjected to abrasion shall be made of antiabrasion materials, or covered with suitable coatings easy to be replaced. Full details of these parts and their materials and thickness must be stated in the offer.

3.4.2.1.2 Design &Erection

- Explosion proof, simplicity, easy cleaning, avoiding improper installation which might cause a malfunction, Suitable tolerance to satisfy safe operation, means of static hazards elimination, low center of gravity to minimize hazard of tipping, minimum number of personnel for operation, abrasion resistance and good surface finish, easy access to any part of silo plant for inspection, maintenance repair.
- All machinery and equipment shall have factory applied permanent name plates, indicating the manufacturers. Serial number, month, year of production and other data necessary to conform to the tender technical specification
- All bearings shall be of the anti-friction, stainless and heavy-duty type, unless working conditions indicate other types, lubricant and grease pipe, extensions to walk way areas shall be provided.
- Equipment with rotary units shall be free of harmful or objectionable vibration at speeds below

3.4.2.1.3 Precautions:-

- Specialists should specify as materials, method of construction and painting to minimize vibration.
- All lubricants exposed to the grains being conveyed shall be non-toxic. All drive lubricating oils shall be mineral oil. Conveyor chains and sprockets shall not be lubricated.

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- Drag conveyor boxes, supports, spouting gates and diverters shall be provided with factory applied standard corrosion-preventing primer and finish paint. Delivery bins, shall be galvanized.
- It is forbidden to use any motors or equipment which can potentially cause sparks. This equipment must be provided with static spark arrestors for prevention of static discharge and hazardous leakage of current.

3.4.2.2 Electric

3.4.2.2.1 Requirements

a) All electrical equipment shall be suitable for tropical conditions, including the Following treatments:

- All insulated impregnated parts (such as motors windings) shall be impregnated with anti-fungal varnish.
- Surface to be painted shall be treated against corrosion
- Unpainted surfaces shall be protected against corrosion

b) All electric motors shall satisfy the following requirements, in addition to the other conditions stipulated:

- Totally enclosed, air cooled, enclosure type IP54 or better.
- The designed continuous output rating of each motor must be at least 15% more than the rated power required by the driven equipment under normal conditions at an ambient temperature of + 50 °C.
- All motors windings shall have at least class F insulation d. 18.4 Starting of motors:
- All motors with power < 5.5 KW shall start directly.
- All motors with power > 5.5KW, shall start with (Star/Delta) switches.

3.4.2.2.2 Precautions

- UPS shall be furnished to ensure field protection and continuous operation of the PLC during any AC power interruption or voltage drop below the range stipulated in the tender documents.
- All insulated impregnated parts (such as motors windings) shall be impregnated with anti-fungal varnish.
- The power factor correction capacitor bank shall be provided to correct the overall power factor automatically to be not less than 0.95.
- -All indicating instruments such as voltmeters, ammeters and KW meter installed on switch boards shall have accuracy ± 1% or better.
- All electrical switch boards and control panels shall comply with international standards specifications

4 Quality Control plan

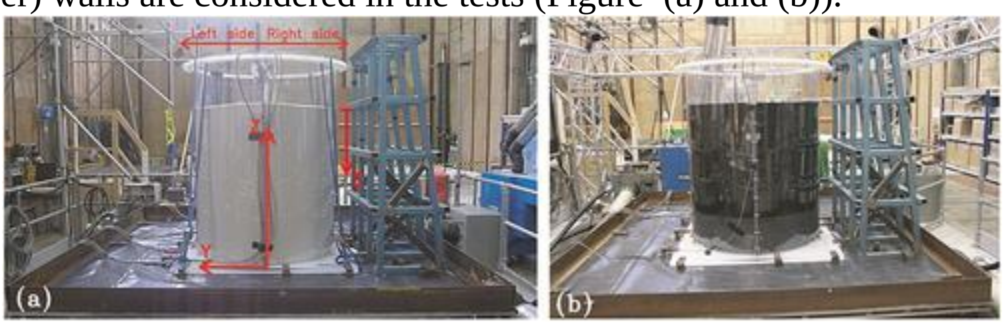
This type of project requires the development and implementation of an integrated quality plan that may sometimes start from the design stage or make a simulation of the origin, follow up the process of quality control, tests and examination, and record the reports linked to it throughout the project.

4.1 Design stage:

Here is an example of tests and research conducted to verify design hypotheses

Experimental test

A circular silo specimen has been developed and realised to meet at best the idealised conditions, upon which the analytical formulation to be verified is grounded. Given that the dimensions of the Earthquake and Large Structures Laboratory (EQUALS) shaking table are 3 × 3 m, the specimen consists of a 1.2-m-diameter, 1.5-m-tall and 3-mm wall thickness polycarbonate container (Figure (a)). The circular silo was produced by bending two polycarbonate sheets to be semicircular in plan and fastening together the adjoining straight edges. Perspex rings encircle the tube at its top and bottom extremities so that it retains the intended shape. Polycarbonate ($E_{polycarbonate} = 2.3$ GPa, $\nu_{polycarbonate} = 0.37$) is selected owing to the relatively low Young modulus, which has the effect of increasing the magnitude of mobilized strain, thereby facilitating its measurement. The base of the container is covered with sandpaper to increase the grain–base friction coefficient, in order to meet the conditions related to the limits of validity of the theory (Eqn 9). Both smooth and roughened (through application of sandpaper) walls are considered in the tests (Figure (a) and (b)).



Figure

4.2 Construction stage

General: Quality plan should touches on

The Plan is a property of the Company, and has been prepared to illustrate Quality Management System as well as a brief identification and description of the Management System Process, determination of procedures necessary to ensure interactions and relations among these processes and to ensure the continuity of

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

Services with a Quality that meets the customers' needs and expectations and Regulatory and Control Authorities. The fundamental understanding and need for quality are an established element in the Contractor culture. The knowledge and importance of achieving quality should be communicated to all staff through a phased awareness program. Customer satisfaction is recognized as an essential business requirement in today's highly competitive environment and this is reflected in the Organization's Quality Policy. External parts from suppliers highly contribute to high quality products, solutions and services have to be offered the customers. To achieve this high-quality level, company's are determined to establish and develop close and long-term relationships with them suppliers or subcontractors. Involvement of them suppliers is managed through this Plan, describing Contractor standardized global approach, setting the minimum required basics tools & requirements. This Company worldwide policy is mandatory to achieve the targets, satisfy the customers and to establish with the panel of supplier's common sustainable growth. All the Contractor processes should be analyzed in detail with Process Owners appointed for all key processes within Core Business Process and for critical support processes. The concept of Process Owners is to ensure that adequate technical competence is available to the understanding and development of Contractor processes and their inter-working. Using the process-based approach has ensured that the quality system has been developed based on business needs and objectives throughout to achieve effective working with full focus on customer requirements, both External and /or internal and external. The Process Owners and their key team members have been trained in process analysis techniques and procedure writing skills to ensure the required capability is available in developing the quality system and its documentation. Subsequently, a quality system has been established based on the detailed analysis of Contractor individual activities and processes and External and /or internal customer / supplier interfacing requirements and mechanisms. The resulting procedures and documentation provide an essential baseline of "know-how" for effective management control, audit and improvement.

4.3 Initial delivery tests

Also, the quality plan must include the initial delivery phase, which is considered one of the most important phases

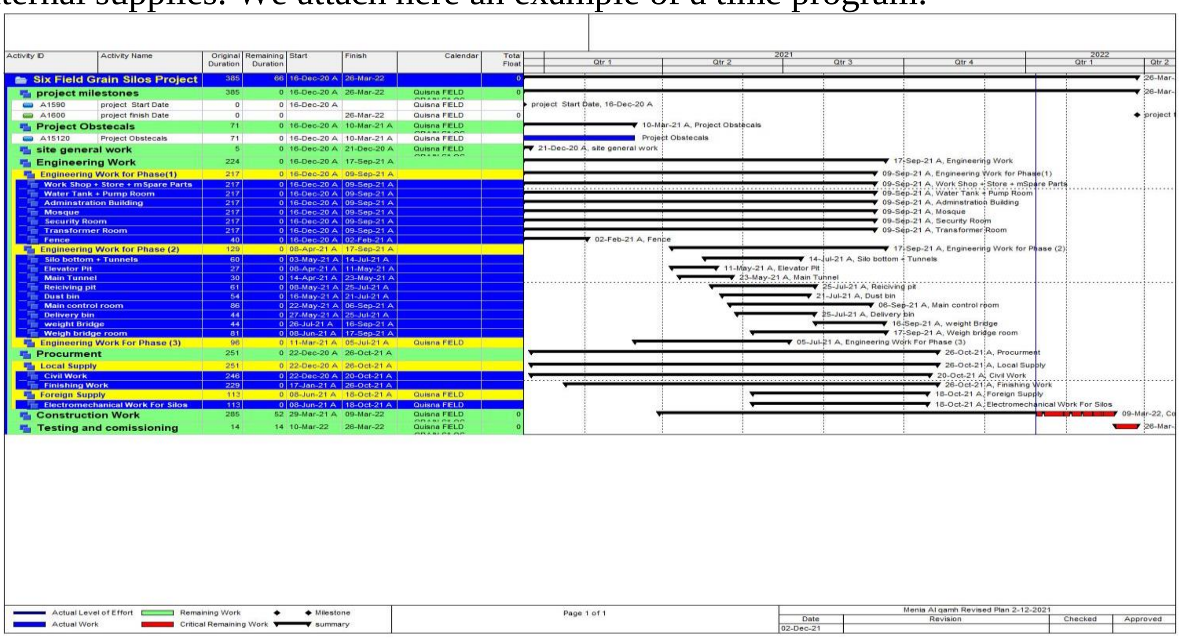
Where the wheat loading test is carried out in two stages

Survey observations should also be taken before and after filling to ensure the stability of the levels and the absence of tendencies, as well as tests of frequencies and vibration measurements.

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

5 Time Schedule

A time SCEDULE is prepared in accordance with the work plan and time requirements for the project such as the beginning and end, loading resources and prices on the various activities and making identification of risks. It is preferable to conduct a detailed study and assessment of risks, taking into account the timing of external supplies. We attach here an example of a time program.



Activity ID	Activity Name	Original Duration	Remaining Duration	Start	Finish	Calendar	Total Float
Six Field Grain Silos Project		385	66	16-Dec-20 A	26-Mar-22		0
project milestones		385	0	16-Dec-20 A	26-Mar-22	Quisna FIELD	0
A1590	project Start Date	0	0	16-Dec-20 A		Quisna FIELD	
A1600	project finish Date	0	0		26-Mar-22	Quisna FIELD	0
Project Obstecals		71	0	16-Dec-20 A	10-Mar-21 A	Quisna FIELD	
A15120	Project Obstecals	71	0	16-Dec-20 A	10-Mar-21 A	Quisna FIELD	
site general work		5	0	16-Dec-20 A	21-Dec-20 A	Quisna FIELD	
Engineering Work		224	0	16-Dec-20 A	17-Sep-21 A		
Engineering Work for Phase(1)		217	0	16-Dec-20 A	09-Sep-21 A		
Work Shop + Store + mSpare Parts		217	0	16-Dec-20 A	09-Sep-21 A		
Water Tank + Pump Room		217	0	16-Dec-20 A	09-Sep-21 A		
Adminstration Building		217	0	16-Dec-20 A	09-Sep-21 A		
Mosque		217	0	16-Dec-20 A	09-Sep-21 A		
Security Room		217	0	16-Dec-20 A	09-Sep-21 A		
Transformer Room		217	0	16-Dec-20 A	09-Sep-21 A		
Fence		40	0	16-Dec-20 A	02-Feb-21 A		
Engineering Work for Phase (2)		129	0	08-Apr-21 A	17-Sep-21 A		
Silo bottom + Tunnels		60	0	03-May-21 A	14-Jul-21 A		
Elevator Pit		27	0	08-Apr-21 A	11-May-21 A		
Main Tunnel		30	0	14-Apr-21 A	23-May-21 A		
Reiciving pit		61	0	08-May-21 A	25-Jul-21 A		
Dust bin		54	0	16-May-21 A	21-Jul-21 A		
Main control room		86	0	22-May-21 A	06-Sep-21 A		
Delivery bin		44	0	27-May-21 A	25-Jul-21 A		
weight Bridge		44	0	26-Jul-21 A	16-Sep-21 A		
Weigh bridge room		81	0	08-Jun-21 A	17-Sep-21 A		
Engineering Work For Phase (3)		96	0	11-Mar-21 A	05-Jul-21 A	Quisna FIELD	
Procurment		251	0	22-Dec-20 A	26-Oct-21 A		
Local Supply		251	0	22-Dec-20 A	26-Oct-21 A		
Civil Work		246	0	22-Dec-20 A	20-Oct-21 A		
Finishing Work		229	0	17-Jan-21 A	26-Oct-21 A		
Foreign Supply		113	0	08-Jun-21 A	18-Oct-21 A	Quisna FIELD	
Electromechanical Work For Silos		113	0	08-Jun-21 A	18-Oct-21 A	Quisna FIELD	
Construction Work		285	52	29-Mar-21 A	09-Mar-22	Quisna FIELD	0
Testing and comissioning		14	14	10-Mar-22	26-Mar-22	Quisna FIELD	0

Actual Level of Effort · Remaining Work · Milestone · Actual Work · Critical Remaining Work · summary

Page 1 of 1

Menia Al qamh Revised Plan 2-12-2021

Date	Revision	Checked	Approved
02-Dec-21			

6 USES OF SILOS:

Grain steel silos

According to the storage materials, there are maize steel silo, wheat steel

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

silo, soybean steel silo, barley steel silo, sorghum steel silo and so on. According to the silo bottom structure, there are concrete hopper bottom steel silo, full steel hopper bottom silo, and flat bottom silo

7 Common types of silos:

7.1 Flat bottom silos

7.2 Conical Silos

8 Components and Brief description

8.1 Components:

Mechanical components Security “risk response” Civil structures

1- Storage bins 1- Magnet 1- Rafts
2- Hoper Intake 2- Dry cleaning 2-Tunnels
3- Scale 3- Temperature measurement 3- structure Skelton
4- Machine Tower 4-Airation system 4- Retaining walls
5- Bucket Elevators 5-Fumigation system 5- Heavy slabs
6- Delivery bins 6-Radar or Laser Systems 6-Deep piles
7- Dust bins 7- Administration
8- Aspiration system 8- Fire Tank
9- Weighbridge 9- Spare room
10- Control; Room
1- Filters
10- Transformer room
12-Conveyors 11-Stores

8.2 Brief

The maximum Storage Silos height restriction is -- m and -- m for the machine tower for all sites. In according to Military Authority approval.

Each storage bin must be equipped with :

- No of aeration fans (fixed) complete and sufficient for aeration of the bin not less than -- m3 per hour for each ton of stored grain
- fumigation systems.

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

The main chain conveyor under each row of bins transfer grain to the elevator, which consequently out load to the delivery bins, or to one of the storage bins during grain circulation

Each silo complex must be capable to receive grain from the trucks. The plant provided with concrete ground hopper, which is covered with a heavy duty, metal grid and reinforced to be strong enough to withstand truck movements. The ground hopper shall be provided with gates or other proper system to regulate the wheat transfer from hopper to drag chain conveyor.

The Silos complex should be equipped with -- elevators. Each elevator should allow simultaneous loading from truck intake to Storage silos or delivery bins, and receiving grain from the storage silos and feeding to either the storage silos or the delivery bins and for recycling from any storage silos to any other grain flow path. Feeding to the elevators is controlled from the control room by remotely operated valves.

The machine tower should be equipped with dust aspiration, waste collection bins, etc. with a capacity of at least -- t/h. for both local and imported wheat.

Grain is distributed to the storage silos by chain conveyors placed on rooftop of the storage silos. and equipped with controlled gate in the bottom of casing

Each plant comprises one out loading delivery silo bin. This bin is fed with grain by bucket elevator through chain conveyor fitted with remote controlled pneumatically discharge valves.

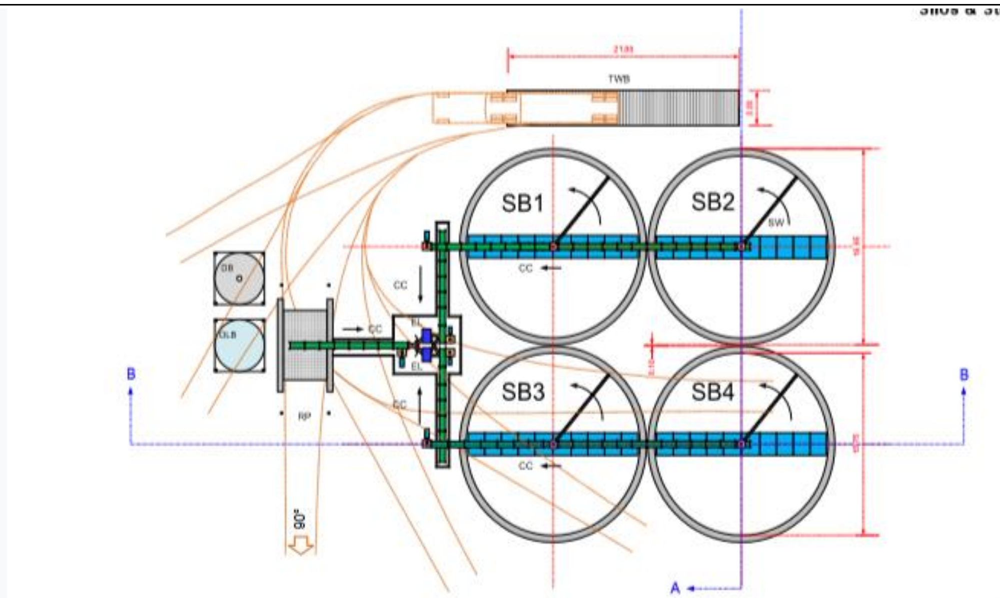
Detailed layout of each site with suitable truck scale --*-- m with -- t capacity, and the surrounding barriers shall be given by the manufactures. Trucks movements inside the site should be taken into consideration to facilitate easy entrance, loading, discharging and exit

At the end of the project, the two CD's loaded with all PLC programs of all the equipment's of the silo.

complex Should be kept

9 General layout

A plan is made for the general site and the locations of the various units and buildings are signed, such as silos, sockets, scales, Machine tower, delivery and dust cells, fire tanks, transformer room, and ancillary buildings, and checking the suitability of their locations and the possibility of maneuvering vehicles and passing on the scale before unloading or loading. Two models for a general site plan are attached.



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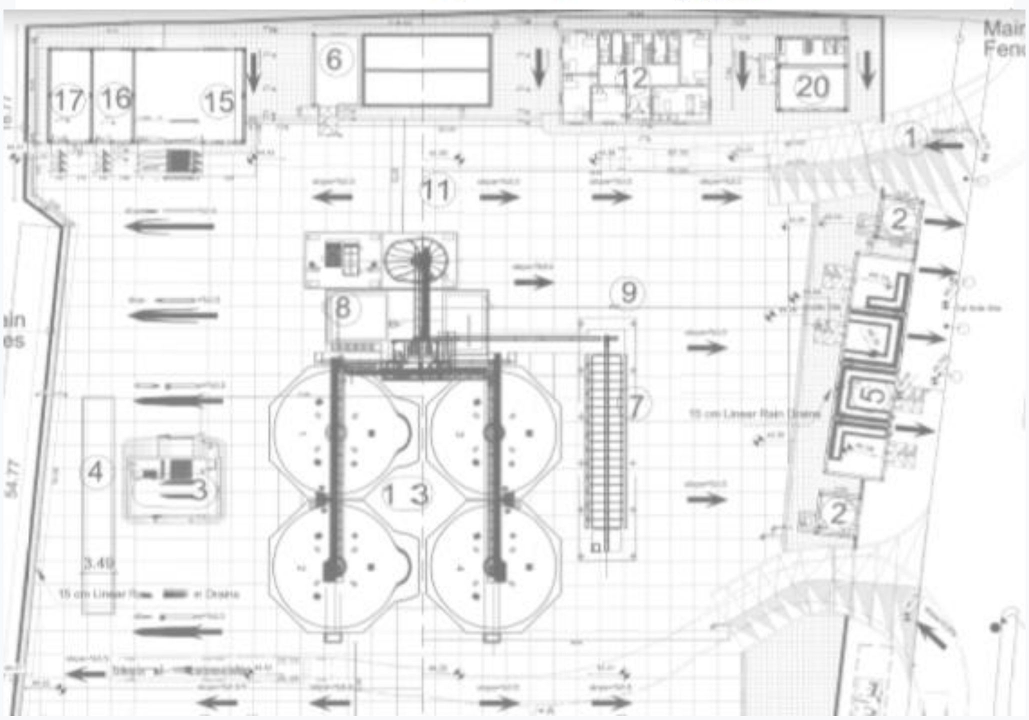

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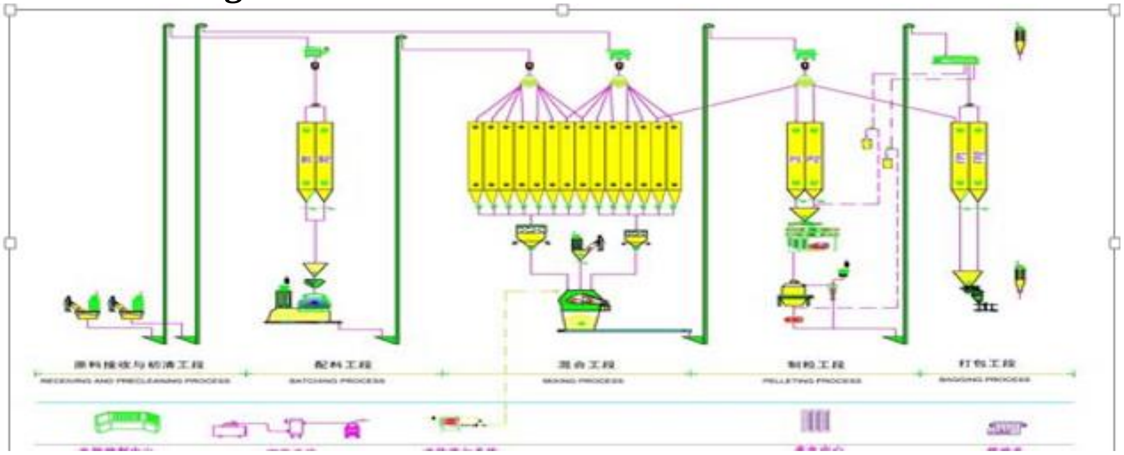
10 Flow diagram



11 MECHANICAL WORKS

11.1 Storage silos

11.1.1 Metallic circular bins: Capacity – ton /h

11.1.2 Walls of bins are to be from galvanized, sinusoidal profiled corrugated Galvanization is not less than -- gm/m2

11.1.3 The design of the bins shall be based on :

The forces resulting from continuous filling and Earthquake loads according to the Egyptian Standard Specifications for each site location - Maximum wind load according to the Egyptian standards specification and other technical requirements

11.1.4 The storage silo bin shall have a corrugated galvanized metal sheet designed to protect the silo bin against rainstorms and bear the weight of the temperature .

11.1.5 Upper walkways .

11.1.6 Complete aeration system

11.1.7 Temperature measuring system.

The temperature measuring cable are installed inside the silo to monitor the material's real time temperature. When the temperature is too high, the ventilation system is started to reduce the material temperature and maintain the material quality

11.1.8 All bins must be prepared for fumigation purposes

11.1.9 Level indicators for grain level:

11.1.10 Sweep Auger (flat bottom silo)

11.1.11 Each bin should be equipped with the following :

- Central bottom discharge

International Journal of Advances Engineering
and Civil Research
Print ISSN 2974-4385 | VOLUME 3, ISSUE 1, 2023, 67 – 99 | Online ISSN 2974-4393

- each bin should be discharged by gravity with a rate equal to the lower chain conveyor capacity (--+ 1h)
- Upper gate
- Inspection and cleaning
- Outside ladder

11.2 Delivery Bin :

Capacity of bin is -- MT

11.3 Truck weighbridge

11.4 Truck intake Hopper (local) :

- Each plant should be provided with a concrete ground hopper for receiving grains in bulk from truck

11.5 Magnet Separators :

- Each plant should include magnet separators with capacity --- t/hr. to separate metal particles from the handled grain with the following specifications
- Tubular Magnet

Tubular Magnet Mainly used to remove the iron impurities from the material

11.6 Machine Tower (local)

A complete steel tower mounted on concrete base as per a specific design, and to comply with the international standards, with enough space to install the main equipment of the silo (bucket elevators, dust collecting units, …….etc.). The tower configuration is to facilitate the easy handling and maintenance of all equipment without any interference. The tower should include stairs, guardrails and covers where necessary, which facilitate easy access to the max height of the

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tower. In addition, the tower should also be provided with a crane of capacity 2 tones for lifting and lowering the equipment and machines. The stairs should be provided with guards to secure maintenance works

11.7 Bucket Elevators

Is used for grain transportation, especially for vertical transportation of grain. Subject to the processing requirements, the capacity of elevator ranges from 10ton per hour to 200ton per hour;
Bucket elevator is a kind of special equipment for continually and vertically grain delivering, which is widely used in different fields such as oil, feed, flour, seed starch, grain and so on. Taking advantage of the present bucket elevator situation both at home and abroad Specification

11.8 - Aeration System

A complete and efficient aeration system for the main storage bins so that each bin shall be provided with a portable fan for suitable aeration according to the international standard specification.

Ventilation system is placed at the bottom of the silo and blow air with fans into the silo through the ring type air duct, so as to reduce the internal temperature of thesilo.Specifications

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

11.9 Gates and spouts :

It is made from steel with suitable thickness according to international standard specifications; it must be self-cleaning, dust tight and free to be coated at the places of possible abrasion.

1.1 <u>Fumigation system</u>

The system shall include distributors of phostoxine tablets and pellets to all storage bins

11.10 Compressor Unit

A complete unit for air compressing designed for supplying compressed air to the different equipment (dust collecting units, gates, valves ….etc.)

11.11 Maintenance Platforms

Sufficient numbers of platforms in the vicinity of each equipment to maintain safety and comfort for maintenance crews shall be provided.

11.12 Dust collecting systems

- Dust shall be collected from bucket elevators, chain conveyors, delivery bins and intake hopper and Weigher. The system must be placed away from the main control room .

11.13 Conveyor

11.13.1 Screw Conveyor

Screw Conveyor is use for grain transportation, especially for

11.13.2 Chain Conveyor

Chain Conveyor is used for grain transportation, especially for

11.13.3 Belt Conveyor

Belt Conveyor is used for grain transportation, especially for horizontal transportation of

11.14 Vibrating Sieve

Vibrating Sieve Mainly used to remove oversized, small, or light impurities from grain such as wheat and paddy. Specifications

11.15 Deck Grain Cleaner

11.15.1 Single

- Single Deck Grain Cleaner Mainly used for cleaning sorghum or powdery materials, It

OR Double Deck Grain Cleaner

11.15.2 Double

- Double Deck Grain Cleaner Mainly used for removing various impurities, large or small,

International Journal of Advances Engineering and Civil Research
Print ISSN 2974-4385 | VOLUME 3, ISSUE 1, 2023, 67 – 99 | Online ISSN 2974-4393

11.16 Laboratory equipment-
11.17 Fire Fighting System_etc)
11.17.1 Fire Pump System
11.17.2 Water fighting system:
11.17.3 Standard pipe and hose system

Drag chain conveyor
Capacity : t/h
Speed :

Table 1

Serial	Elements	Components & Description	Technical Conditions	Remarks
1	Drag chain conveyors housing	Made of steel	Dust and weather tight.	
2	conveyor box			
	bottom	Abrasion resistance	lined with abrasion resistance lining material	
	Side walls	Carbon steel	Covered with abrasion resistance lining material	
	Top cover	Carbon steel	Dust and water tight	
	Bottom and sides		Coat with PEDF	
3	Drag conveyors	Inspection doors	Dust and weather tight	Bedside inlet and out let
		inspection hatch	With suitable mounting assembly	At the discharge end
4	Drag chain	Made of high resistant	A coat of PEHD anti-	

International Journal of Advances Engineering and Civil Research

Print ISSN 2974-4385 | VOLUME 3, ISSUE 1, 2023, 67 – 99 | Online ISSN 2974-4393

		steel	friction nylon	
5	The return chain	Supported by return rollers made of steel		Reduces the noise level
6	All gears and sprockets	Manufactured from heat treated alloy steel		
7	The chain	With suitable tensioning device		
8	The return chain	Supported by return rollers made of st		
9	All gears and sprockets	From heat treated alloy steel	Keyed to carbon steel alloy shaft;	
10	The chain		Provided with suitable tensioning device	
11	All bearings	Bearings should be of heavy-duty type;	Anti-friction with accessible lubrication fittings	
12	Feeders to the drag conveyors		Controlled by a system comprising raised lit and metering slide	
13	Conveyors with multiple discharge and loading openings		Automatically operated gates-Hinged inspection door	
			Glass indicators;	
14	All slide gates	Flanged and drilled sides for booting to the conveyor		
15	The drive unit	Heavy duty type	Capable of starting over- loaded conditions after sudden stop.	
16	The conveyors		Equipped with a zero speed switch to stop the motor automatically.	
17	Minimum required thickness for the conveyor parts			
17-1	a. Casing:	- Min. bottom plate thickness: 4 mm		
		- Min. side plate thickness: 4 mm		

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

		- Min. covers plate thickness: 2.5 mm		
		- Min. bottom lining plate thickness: 10 mm		
		- Min. side lining plate thickness: 6 mm		
17-2	b. Chain guide	Heavy duty steel rollers		
17-3	c. Flights: Min. thickness	8 mm		
18	Other Items			

Table 1

Bucket Elevator
Capacity :
Speed :

Table 2

Serial	Elements	Components-Description	Technical conditions	Remarks
1	All motors	Supplied with hydraulic/soft start couplings.		
2	Bucket elevator	belt and separate bucket type	provided with a suitable belt tensioning device;	
3	The boot	constructed of sheet steel		
		reinforced with angle iron stiffeners skip welded	lined with replaceable abrasion resistant steel	
4	A hinged clean-out door	located below the feed hopper	secured in such a manner to be dust tight	
5	Boot pulleys shaft	equipped with double neoprene layers	misalignment limit switch	
6	The head section	constructed of sheet steel		
		reinforced with angle iron stiffeners skip welded		
7	The discharge Outlet flange	Oriented to discharge vertically downward.	The outlet shall be lined with replaceable abrasion	
			resistant steel or coating of PEHD	
8	The elevator	provided with a steel	provided with means for	

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

		service platform including ladder and handrail	lifting	
	equipped with the following necessary items:			
	a. Doors with chains		To be put at the upper section of bucket elevators;	
	b. Blow-out panels		In each leg of the elevators;	
	c. Inspection door located in the head			
	d. Back stop switch brake		"To be with the gear box";	
	e. Heat detectors for each pulley bearing		To stop the motor when the temperature rises	
	f. Inching-motor "used during maintenance"		To stop the motor when the temperature rises	
	g. Service switch for maintenance		Beside the driving motor;	
9	Boot and head shaft bearings	Mounted external to the casing, Heavy duty sealed	Spherical roller bearings	
11	Fittings for bearing lubrication	be visible and extended to an accessible location for easy maintenance	All lubrication fittings shall be dust-tight;	
12	The head and boot shafts	Protected from dust	Dust must be aspirated from the head and the boot of the elevator	
13	Belt	Spliced with a butt-strap splice	Be oil-resistant, flame retardant, and static conductive.	
14	Other Items			

11.18 Grain Security

Aeration-Magnet –Fumigation –Temperature measurement-Laser or Radar system

12 CIVIL WORKS

12.1 General Requirements

12.1.1 All details, design and workshop drawings for all the civil works (concrete, steel, finishes ...etc.), as well as the calculation sheet Should be Approved Before starting of construction.

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

12.1.2 All materials used, design and execution methods of the civil works have to conform to the most recent updates of the following specifications:

- Egyptian Norms (Egyptian Code for Loads - accounting for wind and earthquake loading according to location of each site, Egyptian Code for Soil Mechanics and Design and Execution of Foundations, Egyptian Code for Reinforced Concrete Structures, Egyptian Specifications for Steel Works, Egyptian Specifications for Sanitary Works)- Egyptian code for roads.Or approved Code and specifications for the project .

- Or international norms (British Standard, DIN, American AC I 318 and A STM

12.1.3 The civil works include but not necessary confined to :-

12.1.3.1 Site preparation
12.1.3.2 Excavation and backfill works
12.1.3.3 Foundations for all structures
12.1.3.4 Storage Silos and delivery bins, dust bin
12.1.3.5 Tunnels
12.1.3.6 Main control room and lifting pit under the machinery tower
12.1.3.7 Truck pit, Weigh Bridge and its control room



12.1.3.8 Firefighting water tank and pump room
12.1.3.9 Transformer room, MV room and distribution room
12.1.3.10 Fresh water and sewage pipes and connections, electrical works and cables necessary for internal lighting
12.1.3.11 Roads and concrete floors including rain water collecting system
12.1.3.12 Fences, guard towers, main gates and security rooms.
12.1.3.13 Septic tank-if needed
12.1.3.14 Building (administration storage external wash rooms, praying area spare part)

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

12.2 Structural Elements

12.2.1 Foundations

12.2.2 Plain Concrete and Reinforced Concrete Works

12.2.3 All concrete and reinforced concrete works are to conform to the latest edition of the Egyptian Code for Design and Execution of Concrete Structures. Or approved Code and specifications for the project

12.2.4 Insulation Works

12.2.5 Storage bins :

1.1.1 Each silo complex consists of metal storage bins as shown in proposed layout

12.2.6 Works for tunnels, truck pit, and lifting pit and weigh bridge

12.2.7 The works consist of reinforced concrete floors and walls .

12.2.8 Water stops

1.1.1 The Buildings

12.2.9 Fences and Gates

12.2.10 The Roads.

13 ELECTRICAL WORKS

In this section, we list, without details, a summary of the electrical work requirements for silos.

13.1 Main Control Room:

13.1.1 Main Distribution Board:

13.1.2 Master Control Panel:

13.1.3 Methods of Operation and Control :

All of the electrical equipment, conveyors, gates etc.... must be operated in two ways :

13.1.3.1 First Method

Remotely, from the main control panel .

Sequential control shall be realized using PLC with possible plant operation and supervised via suitable PC and mimic diagram. The necessary UPS for the PLC and the PC shall be furnished all from the main control room .

13.1.3.2 Second Method -:

Locally, the local operation must include the following:

13.1.3.2.1 Motors:

13.1.3.2.2 . Automatic Sliding Gates:

To be provided with 4 positions switch as follows:

a- Open : The gate is to be opened completely.

b- Remote : The gate is to be controlled from the main Control panel.

c- Off : The gate is to be stopped completely.

d- Close : The gate is to be closed completely.

13.1.3.3 Bucket Elevators

13.1.3.4 Storage silos

13.1.3.5 Direction Switching Gates/Valves:

13.1.4 Inter-Locking:

13.1.5 Operation from the control panel:

13.2 Medium Tension Panel (Local):

13.3 Electric Transformer (Local)

13.4 Power Factor Correction System (Local):

13.5 Communication system (local):

13.6 Air Conditioners (local)

13.7 Electric Cables (local):

13.8 Electric Motors:

13.9 Storage silos Inspection Lamps:

13.10 Earthling System:

13.11 Lightening Protection System:

13.12 Navigation Warning Lights:

13.13 Lighting System:

13.14 Fire Alarm System:

13.15 Maintenance tools and devices

13.16 Temperature measuring system

Silo bins must be provided with heavy-duty temperature cables to measure temperature inside the bins in different places & depth

13.17 Inventory /stock management system (IMS)

ALL Silo bins must be provided with a fully automatic IMS laser scanning system to measure the total volume of grain in each bin individually and summarize the total volume for the whole facility

14 Recommendations

Recommendations Apply project management and quality control methodologies . . Conduct design experiments .

Taking all loads, including those resulting from operating conditions, into consideration Linking site control rooms to central departments . .Design a system to relieve pressure inside the units to avoid dust explosion .Continuous training and awareness for operators.

Print ISSN 2974-4385 VOLUME 3, ISSUE 1, 2023, 67 – 99 Online ISSN 2974-4393

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