МІНІСТЕРСТВО ОСВІТИ ТА НАУКИ УКРАЇНИ
Національний авіаційний університет
Кафедра конструкції літальних апаратів

ДОПУСТИТИ ДО ЗАХИСТУ
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________Святослав ЮЦКЕВИЧ
«___» ____________ 2024 р.

КВАЛІФІКАЦІЙНА РОБОТА
ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ
«БАКАЛАВР»

Тема: «Обладнання санітарного літака»

Виконав:	__________	**Іван ЛОЗОВСЬКИЙ**
Керівник: д.т.н., професор.	__________	**Михайло КАРУСКЕВИЧ**
Нормоконтролер: к.т.н., доц.	__________	**Володимир КРАСНОПОЛЬСЬКИЙ**

Київ 2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aviation University
Department of Aircraft Design

PERMISSION TO DEFEND
Head of the department,
Associate Professor, PhD.
_________Sviatoslav YUTSKEVYCH
"___" ____________ 2024

BACHELOR DEGREE THESIS

Topic: "Equipment for the sanitary aircraft"

Fulfilled by:	____________	**Ivan LOZOVSKY**
Supervisor: **Doctor of Science, professor**	____________	**Mykhailo KARUSKEVYCH**
Standards inspector: **PhD, associate professor**	____________	**Volodymyr KRASNOPOLSKYI**

Kyiv 2024

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Аерокосмічний факультет
Кафедра конструкції літальних апаратів
Освітній ступінь «Бакалавр»
Спеціальність 134 «Авіаційна та ракетно-космічна техніка»
Освітньо-професійна програма «Обладнання повітряних суден»

ЗАТВЕРДЖУЮ
Завідувач кафедри, к.т.н., доцент
________Святослав ЮЦКЕВИЧ
«___» ____________ 2024 р

ЗАВДАННЯ

на виконання кваліфікаційної роботи здобувача вищої освіти

ЛОЗОВСЬКОГО ІВАНА ОЛЕГОВИЧА

1. Тема роботи: «Обладнання для санітарного літака», затверджена наказом ректора від 15 травня 2024 року № 794/ст.
2. Термін виконання роботи: з 20 травня 2024 р. по 16 червня 2024 р.
3. Вихідні дані до роботи: злітна вага літака – 67453 кг, дальність польоту з максимальним комерційним навантаженням 1000 км, крейсерська швидкість польоту 825 км/год на робочій висоті 11000 км, посадкова швидкість 239,6 км/год.
4. Зміст пояснювальної записки: вступ, основна частина, що включає аналіз літаків-прототипів і короткий опис проектованого літака, обґрунтування вихідних даних для розрахунку, розрахунок основних льотно-технічних та геометричних параметрів літака, компонування вантажної кабіни, розрахунок центрування літака, спеціальна частина, яка містить конструкцію ескалатора для нош та аналіз його структурних елементів.
5. Перелік обов’язкового графічного (ілюстративного) матеріалу: загальний вигляд літака (А1×1), компонувальне креслення фюзеляжу (А1×1), креслення ескалатора (А1×1), графічні матеріали виконані в AUTOCAD, презентація PowerPoint.

6. Календарний план-графік:

№	Завдання	Термін виконання	Відмітка про виконання
1	Вибір вихідних даних, аналіз льотно-технічних характеристик літаків-прототипів.	20.05.2024 – 21.05.2024	
2	Вибір та розрахунок параметрів проектованого літака.	22.05.2024 – 23.05.2024	
3	Виконання компонування літака та розрахунок його центрування.	24.05.2024 – 25.05.2024	
4	Розробка креслень по основній частині дипломної роботи.	26.05.2024 – 27.05.2024	
5	Огляд літератури за проблематикою роботи. Проблеми санітарного обладнання.	28.05.2024 – 29.05.2024	
6	Процес проектування обладнання і розрахунки компонентів обладнання	30.05.2024 – 31.05.2024	
7	Оформлення пояснювальної записки та графічної частини роботи.	01.06.2024 – 02.06.2024	
8	Подача роботи для перевірки на плагіат.	03.06.2024 – 06.06.2024	
9	Попередній захист кваліфікаційної роботи.	07.06.2024	
10	Виправлення зауважень. Підготовка супровідних документів та презентації доповіді.	08.06.2024 – 10.06.2024	
11	Захист дипломної роботи.	11.06.2024 – 16.06.2024	

7. Дата видачі завдання: 20 травня 2024 року

Керівник кваліфікаційної роботи ____________ Михайло КАРУСКЕВИЧ

Завдання прийняв до виконання ____________ Іван ЛОЗОВСЬКИЙ

NATIONAL AVIATION UNIVERSITY

Aerospace Faculty
Department of Aircraft
Design
Educational Degree "Bachelor"
Specialty 134 "Aviation and Aerospace Technologies"
Educational Professional Program "Aircraft Equipment"

APPROVED BY
Head of the department,
Associate Professor, PhD.
_________Sviatoslav YUTSKEVYCH
"___"   ____________ 2024

TASK

for the bachelor degree thesis

Ivan LOZOVSKY

1. Topic: "Equipment for the sanitary aircraft", approved by the Rector's order № 794/ст from 15 May 2024.
2. Period of work: since 20 May 2024 till 16 June 2024.
3. Initial data: airplane takeoff weight – 67453 kg; flight range with maximum payload 1000 km; cruise speed 825 km/h at operating altitude 11000 m; landing speed 239.63 km/hour.
4. Content (list of topics to be developed): introduction, main part: analysis of prototypes and brief description of designing aircraft, selection of initial data, wing geometry calculation and aircraft layout, landing gear design, engine selection, center of gravity calculation, special part: conceptual design of the escalator for stretchers.
5. Required material: general view of the airplane (A1×1); layout of the airplane (A1×1); assembly drawing of the escalator (A1×1); graphical materials are performed in AUTOCAD; PowerPoint presentation.

6. Thesis schedule:

№	Task	Time limits	Done
1	Selection of initial data, analysis of flight technical characteristics of prototypes aircrafts.	20.05.2024 – 21.05.2024	
2	Selection and calculation of the aircraft designed parameters.	22.05.2024 – 23.05.2024	
3	Performing of aircraft layout and centering calculation.	24.05.2024 – 25.05.2024	
4	Development of drawings on the thesis main part.	26.05.2024 – 27.05.2024	
5	Review of the literature on the problems of the work. Problems of sanitary equipment.	28.05.2024 – 29.05.2024	
6	Equipment design process and equipment component calculations	30.05.2024 – 31.05.2024	
7	Explanatory note checking, editing, preparation of the diploma work graphic part.	01.06.2024 – 02.06.2024	
8	Submission of the work to plagiarism check.	03.06.2024 – 06.06.2024	
9	Preliminary defense of the thesis.	07.06.2024	
10	Making corrections, preparation of documentation and presentation.	08.06.2024 – 10.06.2024	
11	Defense of the diploma work.	11.06.2024 – 16.06.2024	

7. Date of the task issue: 20 May 2024

Supervisor: ____________ Mykhailo KARUSKEVYCH

Student: ____________ Ivan LOZOVSKY

РЕФЕРАТ

Пояснювальна записка кваліфікаційної роботи бакалавра «Обладнання санітарного літака»:

78 с., 32 рис., 6 табл., 29 джерел

Дана кваліфікаційна робота присвячена розробці санітарного літака для корткомагістральних авіаліній з можливістю транспортування медичне обладнання, медперсонал та пацієнтів з різними типами травм, що відповідає міжнародним стандартам польотів, нормам безпеки, економічності та надійності, а також аналіз та розрахунок основних елементів конструкції ескалатора для нош з пацієнтами.

В роботі було використано методи аналітичного розрахунку, компьютерного проєктування за допомогою CAD/CAM/CAE систем, і стандартні методи розрахунку на міцність.

Практичне значення результату кваліфікаційної роботи полягає у розробці санітарного обладнання літака яке може буде використано в Україні.

Матеріали кваліфікаційної роботи можуть бути використані в навчальному процесі, а також в практичній діяльності конструкторів спеціалізованих проектних установ.

Аванпроект транспортного літака, компонування, центрування, санітарне обладнання, ескалатор

ABSTRACT

Bachelor degree thesis "Equipment for the sanitary aircraft"

78 pages, 32 figures, 6 tables, 29 references

This thesis is dedicated to design of a short-range sanitary aircraft capable of transporting medical equipment, medical personnel, and patients with various types of injuries. The aircraft meets international flight standards, safety regulations, and requirements for economic efficiency and reliability. Additionally, it includes the analysis and calculation of the main structural elements of the stretcher escalator for patients.

The methods used in this work include analytical calculations, computer-aided design using CAD/CAM/CAE systems, and standard strength calculation methods.

The practical significance of the qualification work lies in the development of sanitary aircraft equipment that can be used in Ukraine.

The materials of the qualification work can be utilized in the educational process as well as in the practical activities of designers in specialized design organizations.

Preliminary design of a transport aircraft, cabin layout, center of gravity calculation, sanitary equipment, escalator

Format	№	Designation	Name	Quantity	Notes
			General documents		
A4	1	NAU 24 05L 00 00 00 51 TW	Task for work	1	
	2	NAU 24 05L 00 00 00 51	Short-range cargo aircraft	2	
A1		Sheet 1	General view		
A1		Sheet 2	Fuselage layout		
A4	3	NAU 24 05L 00 00 00 51 EN	Short-range cargo aircraft	78	
			Explanatory note		
			Documentation for assembly units		
A1	4	NAU 24 05L 00 00 00 51	Design of escalator	1	

	Sh.	№ doc.	Sign	Date

NAU 24 05L 00 00 00 51 EN

Done by	Lozovsky I.O.		
Supervisor	Karuskevych M.V.		
St.control.	Krasnopolskyi V.S.		
Head of dep.	Yutskevych S.S.		

Preliminary design of
short-range cargo
aircraft
(Qalification work)

list	sheet	sheets
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CONTENT

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Head of dep.	Yutskevych S.S.						

INTRODUCTION

Bachelor thesis deals with an actual problem of aircraft equipment.

Aim of the work: to develop original equipment for the sanitary aircraft.

To achieve that aim the following tasks are solved:

- To make preliminary design of the short range cargo aircraft with cargo capacity – 20000 kg;
- In the process of the aircraft centering calculations to account for the accommodation of special sanitary equipment;
- To find out key elements of the sanitary equipment at the concept level;
- To ensure reduction of the loading duration and shorten human force consumption by the application of escalator for stretchers;
- To make calculations of escalator’s bearing elements strength;
- To define further steps for the sanitary equipment design.

The design method is implementing the analysis of prototype and incorporate the improving technological decisions, the study of the selection of the engines were could be fitted on the designing aircraft, selection of the tires of the designing undercarriage by using the primary data of designing aircraft, engineering analysis to acquire the efficient technical data of the designed aircraft and computer aided design using CAD systems. In special part the modeling and calculation of the strength and loads are used to estimate stress state of the escalator`s parts.

This work has the practical value: to improve the special equipment of medical aircraft. The purpose of the presented work is the development of a lifting mechanism for stretchers. This design is supposed to be an aircraft optimized for short haul transport, with a maximum takeoff weight of 67453 kg.

The aviation industry allowed us to transport goods from one place to another shortly and without delay, especially in situational emergences.

The rapid transport of cargo has always been essential in aviation and critical for its success. For this particular project, we will be working with the Antonov 178 (An-178) and Embraer C-390 transport aircraft; These jets have a very nice payload capacity, robust engineering as well as proven use. The planes will be completed with advanced life-support equipment and capability for wounded military personnel, thus ensuring their invaluability in wartime and emergency zones.

Equipped with state-of-the-art medical equipment and room for injured troops, the new aircraft will prove invaluable in war zones or areas hit by natural disasters. Enhencement of sanitary aviation is needed to provide humanitarian and medical relief and to advance aerospace technology, which can perform overall aims of aerospace architecture for quick delivery of precise treatments. The sections below will describe the design needs, engineering obstacles and technical advancements requiring such kind of special transport planes. This technology has the potential to save lives and protect those who are answering front-line calls.

1. PRELIMINARY DESIGN OF SHORT-RANGE CARGO AIRCRAFT

1.1 Analysis of prototypes and short description of designed aircraft

The preliminary design process is based on the analysis of advanced contemporary planes, first of all those designed by ANTONOV Company.

The An-178, manufactured by the ANTONOV Company in Kyiv, Ukraine, is a short-range transport aircraft powered by two turbofan engines. It is a modern high-wing transport aircraft featuring a sleek, streamlined design [1]. Designed as a replacement for outdated military transport planes, the An-178 shares key avionics and engines (D-436-148FM) with the An-148 series. Its cargo capacity 15-18 tons. It has a distinctive, slender fuselage with a spacious cargo hold and large cargo doors, facilitating easy loading and unloading of freight. The aircraft is equipped with efficient turbofan engines, giving it the ability to operate effectively over short to medium ranges. It has a robust landing gear system suitable for operations on various types of runways, including unpaved surfaces. The overall design emphasizes versatility and efficiency, making it well-suited for diverse transport and logistical operations. The T-type tail unit of the An-178 is a distinctive feature of its design, contributing to the aircraft's stability and control during flight. It consists of a central vertical stabilizer forming the vertical part of the "T" shape, aiding in maintaining directional stability. The horizontal stabilizers are attached to the top part of the vertical stabilizer and play a crucial role in pitch controlling of the aircraft.

The C-390 is the brand new technology army multi-mission airplane that brings unequalled mobility, excessive productiveness and operation flexibility at low operational expenses on a single and particular contemporary-day platform [2].

The C-390 exhibits the capability to transport and deploy both cargo and troops, undertaking a diverse range of missions such as medical evacuation, search and rescue, humanitarian assistance, aerial refueling for fighters and helicopters,

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Head of dep.		Yutskevych S.S.			

aerial firefighting, and more. Its state-of-the-art Cargo Handling System (CHS) complements flexibility and productiveness through integrating a current, software-controlled cargo locking solution with established mechanical cargo handling mechanisms. The CHS is designed to be without problems and fast reconfigured for special missions without the need for unique tools. The floor of the cargo of the KC-390 may be converted from a flat surface to a configuration with rollers with the ability to flip over. The KC-390 MILLENNIUM is equipped for refueling both fixed-wing and rotary-wing aircraft, functioning at speeds ranging from 120 knots calibrated airspeed (KCAS) to 300 KCAS and at altitudes between 2,000 feet and 32,000 feet. Additionally, the on-ground refueling capability of the KC-390 MILLENNIUM can be utilized to refuel vehicles or support forward operating bases. During Search and Rescue missions, each minute counts to store lives. The C-390 MILLENNIUM turbo fan engines offer incomparable speed in comparison with different aircraft. That aircraft can be equipped with a whole set of system to assist Search & Rescue missions. The ability to connect and detach inner fuel tanks complements the C-390 MILLENNIUM`s range or duration on station, making it a perfect desire for Search & Rescue missions a real first responder.

Aeromedical evacuation: C-390 MILLENNIUM gives help for ground operations or catastrophe relief missions transporting injured survivors. The C-390 MILLENNIUM may be organized to house a maximum of seventyfour litters (STANAG 2040) and an extra eight individuals, comprising medical attendants and crucial life-supporting equipment.

The main parameters of the prototypes, power plant parameters, take-off and landing characteristics are presented at the table 1.1.

Table 1.1

Performances of prototypes

Name and dimensionality	An-178	Embraer C-390
1	2	3
Max payload, (kg)	18000	26000
Crew, number of pilot	2	2 pilots + 1 loadmaster
Wing loading, (kgf)	51000	–

Ending of the table 1.1

1	2	3
Maximum Flight Range (km)	1000	2600
Cruise Altitudes, (km)	11	11
Thrust to weight ratio (N/kg)	2.7	3.2
Number of engines and their type	2 × D-436-148FM turbofan	2 x IAE V2500-E5 turbofan
Take off thrust, (kN)	77.28 × 2	139.4 × 2
Cruising thrust, (kN)	16.67 × 2	–
Spec. fuel cons., take off, (kg/(kNh))	37.72	–
Spec. fuel cons., cruising, (kg/(kNh))	63.71	–
Trust to weight ratio	4.57 - 4.88	4.18 - 5.73
Pressure ratio	25.2 : 1	36.2 : 1
Bypass ratio	4.95 : 1	4.7 : 1
Wing span, (m)	30.57	35.05
Fuselage length, (m)	32.23	35.2
Fuselage diameter, (m)	3.95	4
Fuselage fineness ratio	8.16	8.8
Cabin width, (m)	2.73	3.45
Cabin length, (m)	16.54	18.5
Cabin height, (m)	2.73	2.95
Cruise speed, (km/h)	825	870
Max. speed (km/h)	990	988
Speed of take-off, (km/h)	277.68	–
Landing speed, (km/h)	245.12	193
Landing run distance, (m)	792	–
Take off run distance, (m)	1010	1524
Landing distance, (m)	1313	1000
Maximum Take Off Mass, (kg)	51000	87000
Landing mass, (kg)	34400	65400
Empty weight (kg)	23820	39400
Fuel fraction, %	28.7	26.43
Payload fraction, %	35.3	29.88

1.2 Brief description of the main parts of the aircraft

1.2.1 Wing

During the aircraft design, a high-wing configuration was chosen to facilitate cargo loading and unloading. A swept-back wing design was incorporated to enhance aerodynamic performance at higher speeds, and winglets were added to reduce drag and improve fuel efficiency. A moderate aspect ratio for the wing was selected to balance lift efficiency and maneuverability. The wing is equipped with leading-edge slats and trailing-edge flaps to provide enhanced lift during takeoff and landing and improve stability at low speeds. Control surfaces consist of ailerons, spoilers, lift-dump/speed-brake spoilers, rudder, and elevators, with an emergency mechanical cable backup system for safety. Integrated fuel tanks in the wings improve fuel storage, distribution, and weight balance.

The wing structure is made from lightweight alloys and composites to optimize the strength-to-weight ratio. Winglets also help reduce fuel consumption and emissions, contributing to environmental sustainability. They work by mitigating induced drag, a byproduct of lift, enhancing the lift-to-drag ratio and allowing for more efficient flight [3].

1.2.2 Fuselage

The planned airplane features a semi-monocoque structure, utilizing advanced materials and manufacturing techniques to ensure quality, durability, and weight efficiency. Its fuselage is primarily constructed from lightweight aluminum alloys, providing a balance between strength and weight. Divided into forward, midsection, and rearward segments, these parts are typically built separately and then assembled during manufacturing.

The structural framework consists of longitudinal stringers and circumferential frames, working together to distribute loads and ensure overall fuselage strength. What distinguishes it from modern cargo planes is its use of lightweight yet highly durable metals and composite materials. Safety and comfort extend to the cargo compartment, equipped with features such as Automatic Temperature Control, Reduced Vibration and Noise, a complete Toilet with External Service, Appropriate Signaling and Emergency Exits, and an Emergency Oxygen System [4].

The spacious cabin ensures comfort for crew and medical staff during extended flights. The modern Air Conditioning and Pressurization System, combined with the aircraft's wider cross-section and heated floor in the cargo compartment, enhances comfort during missions involving passengers in the cargo cabin. The cargo compartment dimensions allow for the transport of various general cargoes.

1.2.3 Tail unit

The T-tail configuration provides some advantages. The essential benefit is that it is out of the areas of wing vortices, wing wake. Also, another fundamental advantage is that it is out of the zones of wing downwash, and motor go out stream (i.e. warm and turbulent over the top speed gas). The decreased effect from the wing consequences in a smaller horizontal tail area, at the same time as the reduced impact from the engine conducts to much less tail buffet and vibration. This reduction in tail vibration enhances the toughness of the tail, minimizing fatigue issues. Another advantage of the T-tail configuration is the effective impact of the horizontal tail at the vertical tail. It is known as the end-plate impact and outcomes in a smaller vertical tail area. The elevated horizontal stabilizer of the T-tail configuration allows reduce interference drag, as it is situated above the turbulent airflow generated by the wings and fuselage. This contributes to improved overall aerodynamic efficiency. In military and humanitarian missions, transport aircraft may operate from unpaved or rough airstrips. The T-tail configuration provides greater clearance over the ground, reducing the risk of damage to the tail structure during takeoff and landing. The T-tail design reduces the likelihood of a tail strike during takeoff or landing, particularly in situations where the aircraft experiences a steep climb angle or a high sink rate. The absence of a horizontal stabilizer at the rear part of the fuselage allows for a more flexible and efficient cabin layout, which can be advantageous for medical evacuation missions.

1.2.4 Landing gear

The retractable landing gear includes two main wheel bogies and a dual nose wheel. Four-wheel main landing gear on the left and right sides and two-wheel nose undercarriage provide efficient landing and takeoff for airfield operations. They also provide good shock-absorbing properties when used on damaged runways. For airfields of landing categories, I and II, certain conditions must be met. One of the conditions is that the adhesion coefficient must exceed 0.3. On the runway, situations can vary, such as a dry runway, a wet or frosted runway, a wet runway with areas of ditch water up to ten mm deep, or no areas of ditch water. Also, the runway can be covered with slush up to fifteen mm thick, dry snow thickness of which is not exceed 50 mm thick, or wet snow, the thickness of which not more than 15 mm. These situations also occur on unpaved runways [5].

1.2.5 Cockpit

The cockpit is a crucial area where the flight crew operates and controls the aircraft. The cockpit design is based on the An-178 aircraft. It features modern avionics, control systems, and instrumentation. The layout provides an ergonomic and efficient working environment for the flight crew. The cockpit houses various instruments, including flight displays, navigation systems, communication equipment, and engine controls. The flight crew can monitor critical parameters such as altitude, airspeed, attitude, and engine performance [4]. It has a two-person flight crew: a pilot and a co-pilot. The cockpit seats are designed for comfort during long flights. The cockpit windows provide excellent visibility for takeoff, landing, and in-flight operations. Moreover, the new aircraft is prepared with a complicated Tactical Radar, providing spotlight synthetic aperture radar, air-to-air, weather, air-to-ground navigation, and high-decision modes. The aircraft boasts outstanding cockpit visibility and ergonomics, ensuring a high level of functionality for the flight crew. Remarkable is the full night vision compatibility of the interior, exterior, and cockpit systems. There is an emergency hatch for evacuation of personnel at emergency situations.

1.2.6 Control system

One of the main characteristisc of an airplane is a dual-duplex fly-by-cord device, including parts: FCS-A and FCS-B [6]. Each component is liable for to prevent moisture loss and 2 manage channels. The control surfaces for flight consist of ailerons close to the wingtips, spoilers, lift-dump/speed-brake spoilers, rudder, and elevators. An emergency mechanical cable backup device is likewise available.

1.2.7 Onboard equipment

Medical units are set up inside the aircraft, equipped with all necessary equipment: monitoring devices, artificial ventilation apparatus, and continuous medication delivery systems. Intensive Care Unit Block consists some parts like: a) life function monitors: measure heart rate, arterial pressure, oxygen levels, and other vital parameters. (videotoracoscope, videobronchoscope, 128-slice computer tomograph); b) lung ventilation machines: provide respiratory support to patients; c) infusion pumps and systems: administer medications and fluids intravenously; d) electrocardiographs (ecg): used to monitor the patient's heart condition; e) intensive resuscitation unit block; f) defibrillators: administer electric shocks to the heart to restore normal rhythm; g) portable devices for narcotic administration: for pain relief and control; h) infusion pumps with narcotic drugs: manage pain and other symptoms; i) patient temperature control systems: manage the patient's body temperature; j) traumatology and surgery equipment; k) surgical equipment: includes surgical instruments, lighting systems, sterile kits; l) telemedicine systems: For remote consultation of doctors and transmission of medical data [7].

Surgical equipment and specialists are needed for performing emergency interventions and monitoring the patient's condition. Intravenous lines, drains, and tubes must be patent and securely fastened to ensure continuous medication delivery and fluid drainage. Pleural drainage tubes and Heimlich valves are used to prevent and treat chest trauma during transportation. Foley catheters and nasogastric tubes should remain in place and ensure drainage. Blankets and thermal wraps provide thermal protection for the patient in cold weather or postoperative hypothermia. Stretchers with straps have three straps for patient fixation, ensuring safety during the flight. Oxygen masks and oxygen delivery systems are essential to ensure adequate oxygenation at low oxygen pressure at altitude. Re-expansion systems, such as Heimlich valves, are used for treating pneumothorax. Finally, humidity systems are needed to prevent loss of moisture and mucosal obstruction in patients with burns or those at risk of airway blockage [7].

Temperature control equipment maintains the desired temperature in the aircraft cabin, which can range from 15°C to 35°C depending on the season. Non-invasive blood pressure monitoring or intra-arterial catheters used for monitoring blood pressure when auscultation is impossible due to noise. Hearing protection for patients is important for protection the patient’s hearing in a noisy aircraft environment. These devices and equipment are essential for ensuring the safety and comfort of patients with various medical conditions during air transport [7].

1.2.8 Choice and description of power plant

The D-436-148FM engine is a joint development by Ukrainian Manufacturers Motor Sich JSC and Ivchenko-Progress State Enterprise, specifically designed for the new Ukrainian transport aircraft An-178. It is distinguished by increased thrust at all engines` main operating modes, and in the takeoff mode, the thrust is increased to 7700 kgf (75.51 kN), with improved emission characteristics. Compared to its passenger predecessor, the new modification has increased thrust in all main engine operating modes and improved emission characteristics, even as on the identical time it has at least 10% lower cost than foreign analogues. Effective sound-absorbing structures are implemented to reduce noise to the engine profile. The D-436-148FM engines follow all modern ICAO requirements concerning environmental and noise levels [8, 9]. Owing to high-wing role a new airplane may be protection operated from/to huge charge of airfields with extraordinary traits of runways. The engine performances are described in table 1.2.

Table 1.2

Engine performances

Model	Dry weight	Take-off thrust/max. emergancy	Bypass ratio	Dimensions	Take-off mode. Specific fuel consumption	Max. Cruising mode. Specific fuel consumption
D-436-148FM	1450 kg	75,51 kN/84.34 kN	4.95	3694×1784×1930 mm	38.7 kg/N*h	63.7 kg/N*h

Conclusions to the analytical part

The high-wing transport aircraft described here has been equipped with sophisticated features and designs to improve aerodynamic performance, operating efficiency, and mission adaptability. Notable features include the use of lightweight yet durable materials in the semi-monocoque circular cross-section fuselage, a high-aspect ratio swept wing with winglets for improved fuel efficiency, and a T-tail configuration that offers several advantages such as reduced interference drag and improved ground clearance. The aircraft's cockpit and cargo compartment are designed to prioritize functionality and comfort, with modern systems ensuring night vision compatibility and efficient air conditioning and pressurization.

The landing gear configuration supports various types of operations, including soft airfields and damaged runways. Overall, the aircraft's design is geared towards versatility and adaptability for diverse military and humanitarian missions, showcasing a commitment to efficiency, safety and sustainability.

2. AIRCRAFT MAIN PARTS CALCULATIONS

2.1 Geometry calculations of the main parts of the aircraft

2.1.1 Wing geometry calculation

For the designed aircraft, initial data are calculated in NAU’s department of aircraft design. During the preliminary design phase, the usual practice is to select a wing from the large number of wings with geometric and aerodynamic characteristics available in the aeronautical literature. The design of the aircraft's wing incorporates a supercritical airfoil, chosen specifically for its aerodynamic properties. The relative thickness of the airfoil measures at 0.118, contributing to the overall efficiency of the wing design. Positioned with a high-wing configuration on the fuselage, the wing's aspect ratio is set at 10.7, indicating its length and span relationship. The taper ratio of the wing is determined to be 3.75, a critical parameter influencing various aspects of the aircraft's performance, including induced drag, structural weight, and ease of fabrication. Additionally, the sweep back angle of the wing is set at 27 degrees, further enhancing the aerodynamic characteristics of the aircraft. This angle plays a crucial role in controlling airflow over the wing and affects stability and handling. To calculate the wing area, we refer to the wing loading and gross weight, both of which have been predetermined and documented in appendix A.

Full wing area is:

$$S_w = \frac{m_0 \cdot g}{P_0} = \frac{67453 \cdot 9.81}{4218} = 156.72\left(\mathrm{m}^2\right),$$

where m_0 – take-off weight, kg; g – gravity acceleration, m/s^2; P_0 – specific wing load, N/m^2. Relative wing extensions area is 0.01.

After the calculation, the new numeric value of the wing area was compared with a wing area of prototypes. So, the wing area is 120 m^2 was taken. Because, the calculated value was too high. The changing of the wing area of an airplane can affect its flight characteristics and overall performance in different conditions. That is why altering of the wing area was considered. The main reasons are: a) increasing the wing area can enhance lift and improve takeoff and landing characteristics.

Compared to the wing of the An-178, the wing area of the new aircraft is larger; b) fuel efficiency: optimizing the wing area can influence aerodynamic characteristics and, consequently, fuel efficiency. Increasing the wing area may reduce induced drag and improve the lift-to-drag ratio, leading to better fuel efficiency; c) adaptation to different flight modes: aircraft are often designed for a wide range of missions, and variable wing area can help adapt the aircraft to different flight modes, such as cruising, takeoff and landing, maneuvering, etc;

Wing span is:

$$l_w = \sqrt{S_w \cdot \lambda_w} = \sqrt{120 \cdot 10.7} = 35.83\,(\mathrm{m}),$$

where λ_w – wing aspect ratio.

Root chord is:

$$C_{root} = \frac{2S_w \cdot \eta_w}{(1+\eta_w) \cdot l_w} = \frac{2 \cdot 120 \cdot 3.75}{(1+3.75) \cdot 35.83} = 5.29\,(\mathrm{m}),$$

where η_w – wing taper ratio.

Tip chord is:

$$C_{tip} = \frac{C_{root}}{\eta_w} = \frac{5.29}{3.75} = 1.41\,(\mathrm{m}).$$

On board chord for trapezoidal shaped wing is:

$$C_b = C_{root} \cdot \left(1 - \frac{(\eta_w - 1) \cdot D_f}{\eta_w \cdot l_w}\right) = 5.29 \cdot \left(1 - \frac{(3.75-1) \cdot 3.95}{3.75 \cdot 35.83}\right) = 4.85\,(\mathrm{m}),$$

where D_f – fuselage diameter.

Detetmination of the type its internal design is needed to choose the structure scheme of the wing. To meet the requirements of strength, the torsion box type with two spars was selected.

For a wing with two spars: $x_{1spar} = 0.2 \cdot C_i$; $x_{2spar} = 0.6 \cdot C_i$ from the leading edge of current chord in the wing cross-section. Relative coordination of the spar’s position is equal:

$$x_{1spar} = 0.2 \cdot 5.29 = 1.06\,(\text{m}).$$

$$x_{1spar} = 0.6 \cdot 5.29 = 3.17\,(\text{m}).$$

A geometric method to determine the mean aerodynamic chord has been applied, which is presented on figure 2.1.

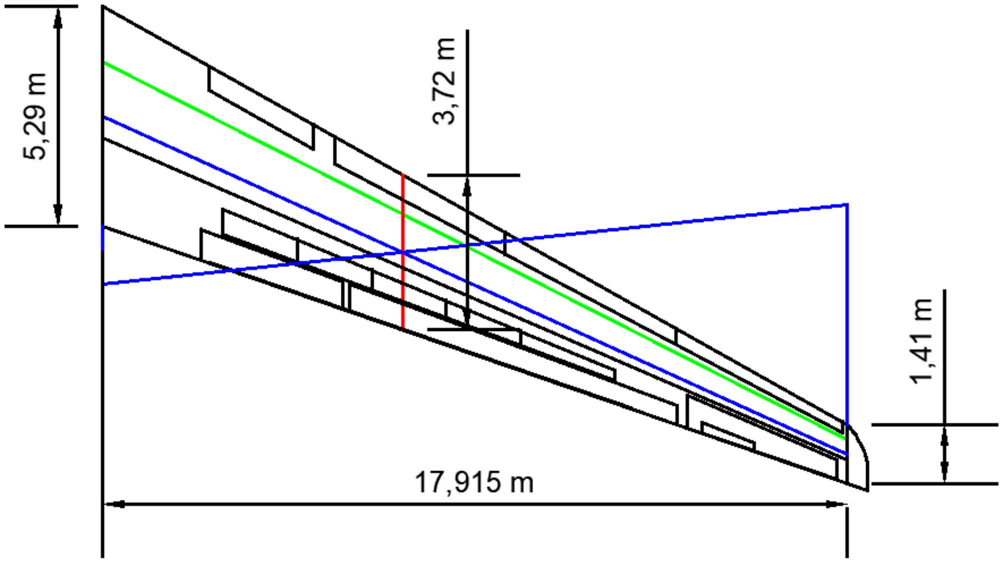


Fig. 2.1. Geometrical determination of mean aerodynamic chord.

To check the geometrical method of mean aerodynamic chord determination we could calculate the MAC by the approximately formula:

For trapezoidal wing shape:

$$b_{MAC} = \frac{2}{3} \cdot \left(\frac{C_{root}^2 + C_{root} \cdot C_{tip} + C_{tip}^2}{C_{root} + C_{tip}} \right) = 3.72\,(\text{m}).$$

After the geometrical characteristics of the wing were calculated, the estimation of the aileron’s geometry and high-lift devices was started. Rolling moment creation and provide adequate rate of roll are the main purposes of the ailerons.

Ailerons geometrical parameters are determined in next consequence:

Ailerons span:

$$l_{aileron} = 0.4 \cdot \frac{l_w}{2} = 0.4 \cdot \frac{35.83}{2} = 7.17\,(\mathrm{m}).$$

Ailerons chord was chosen according to the prototype. Root part is equel to 0.47 m and root part is 0.78 m. In addition to this, it was decided to choose the aileron area the same as for the An-178 and it is equel to 4.68 m^2.

Ailerons are equipped by the secondary control surfaces (aerodynamic balance).

Inner axial balance:

$$S_{in.axial} = 0.3 \cdot 4.68 = 1.4\,(\mathrm{m}^2).$$

For the aircraft with two engines:

$$S_{trim.tab} = 0.06 \cdot S_{aileron} = 0.06 \cdot 4.6772 = 0.28\,(\mathrm{m}^2).$$

Range of aileron deflection: upward $\delta_{aileron} \geq 25°$ downward $\delta_{aileron} \geq 15°$.

The purpose of determining the geometric parameters of the wing lifting devices is to provide the take-off and landing coefficients of the wing lift force, which were assumed in the previous calculations with the chosen rate of high-lift devices and the airfoil type profile.

High-lift coefficient is 0.97. So, the aircraft will have double slotted flaps together with slats. The rate of the relative chords of wing high-lift devices in the modern design are:

$$C_f = 0.3 \cdot C_i = 0.3 \cdot 5.29 = 1.59\,(\mathrm{m}).$$

$$C_{f2} = 0.3 \cdot C_i = 0.3 \cdot 1.41 = 0.42\,(\mathrm{m}).$$

For slats:

$$C_S = 0.15 \cdot C_i = 0.15 \cdot 5.29 = 0.79\,(\mathrm{m}).$$

$$C_S = 0.15 \cdot C_i = 0.15 \cdot 1.41 = 0.21\,(\mathrm{m}).$$

2.1.2 Fuselage layout

The fuselage diameter is 3.95 m [5]. The fineness ratio of the aircraft is 8.16. Length of aircraft fuselage forward part (fig. 2.3):

$$L_{fwd} = FR_{np} \cdot D_{fus} = 1.5 \cdot 3.95 = 5.93\left(\mathrm{m}\right).$$

Length of the fuselage tail part (fig. 2.3):

$$L_{tail.part} = FR_{tp} \cdot D_{fus} = 1.881 \cdot 3.95 = 7.43\left(\mathrm{m}\right).$$

Cabin design is similar to the prototype (fig. 2.2).

Cabin length – 16.54 m. Fuselage sections are shown on figure 2.3.

Cabin width and height – 2.73 m. It is shown on figure 2.4.

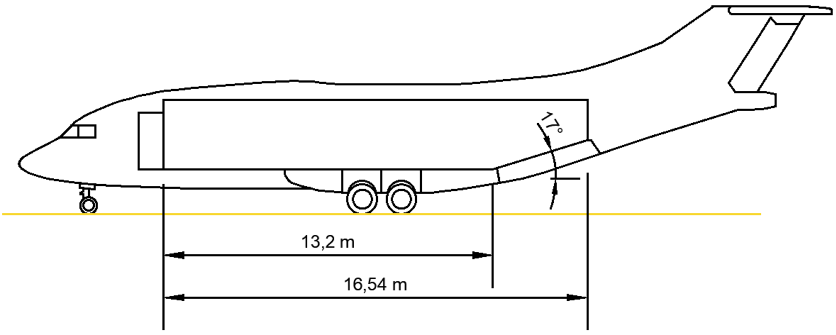


Fig. 2.2. Main geometrical parameters of cabin.

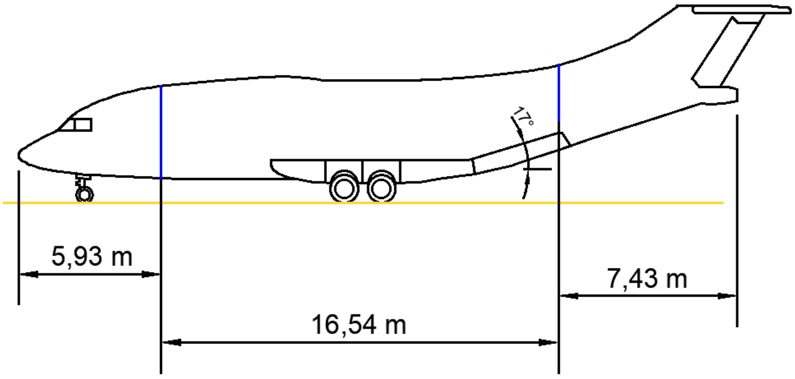


Fig. 2.3. Fuselage sections.

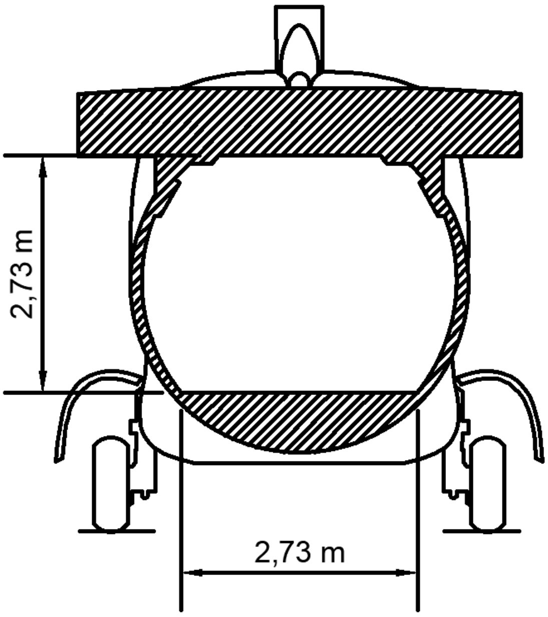


Fig. 2.4. Cabin width and height.

2.1.3 Door and ramp

Quantity and type of exits installed on each side of the fuselage depends on the maximum allowable passengers` seats permitted. For a passenger seating arrangement of 20 to 40 seats, according to the CS 25.807 (g)(4), at least two exits there must be, one of which must be a Type II or larger exit, on each side of the fuselage. So far as, the new aircraft will be the cargo type, it was considered to mount the Type A door and the ramp. Type A door is a floor-level exit with dimensions: not less than 1.0668 m wide by 1.83 m high. Also it has a rectangular opening. That decision was made, because embedded Type A door is big enough for effective means of passenger evacuation [10]. It will be located at the left forward part of the fuselage for better access for the medical staff and flight attendance. Also, stairs will be integrated. The new aircraft is equipped with a cargo hatch in the tail section, which consists of a ramp, hatch, pressure shield, and attachable ramps. In the open position, the cargo hatch is used for loading (unloading). When closed, it ensures the fuselage's airtightness and the aerodynamic contour of the tail section.

The ramp is hinge-mounted on frame 36, equipped with two drive hydraulic cylinders, closed position locks, and two manually adjustable stops for securing it in two fixed positions ("0°" and "-14°"). In the closed position, the ramp is held by locks on the right and left sides, located under the beams of the cargo hatch. When opening the cargo hatch on the ground, the ramp lowers to the ground by its supports (when the aircraft is in the "squatted" position) or hangs on the rods (without the aircraft "squatting"). When the cargo hatch is open on the ground, ramp sections can be manually installed on the rear end of the ramp, with the possibility of adjusting them for different wheel track widths of wheeled cargo.

The designing aircraft is provided for the transportation of 7 handicapped people on the stretchers. They will be installed in two rows. Inside the forward part of the cabin there will be 10 seats for medical staff, two rows by two seats on the right side of the cabin and three rows by two seats on the left side. Floor area without cargo ramp 39 m^2 and with cargo ramp 58.5 m^2. The length of the ramp is 3.4 m. And The width of the ramp is 2.73 m.

In addition to this, a special room will be installed in the cabin for a patient who will need immediate medical attention. In it, medical staff will be able to perform more difficult operations. This room will have all the necessary medical equipment and instruments, as well as a washbasin. If a patient outside this room needs medical equipment, then the medical staff will be able to take all the necessary equipment from this room.

The Cargo Hatch Control System (CHCS) must fulfill various configurations when the cargo hatch is open, including securing the ramp on the floor plane, lowering it to the ground, or holding it in intermediate positions. It also includes features for securing the hatch with additional locks for overhead loading equipment, as well as options for opening the hatch independently of the ramp to perform cargo drop or cabin ventilation. The system also manages the closing of the cargo hatch. The ramp functions under specific conditions required for prototype aircraft, including ambient temperatures ranging from +50 to -60°C, altitudes up to 4000 ± 200 meters above sea level, and speeds up to 360 km/h (194 knots).

The hatch lock drive is mechanically linked to the ramp lock hook stops and the pressure shield blocking mechanism. In the open position, the hatch is secured by a self-locking lock with a hydraulic cylinder drive. The pressure shield, mounted on frame 50, includes a hydraulic cylinder drive connected to a two-link mechanism with kinematic locks in the closed position and self-locking locks in the open position. Additionally, blockers ensure closure if the ramp lock hooks are not engaged. The force of the pressure shield's hydraulic cylinder is calculated to overcome the excess pressure acting on the pressure shield of less than 0.02 kgf/cm² (0.284 psi). The ramp option provides the ability for isolated ramp control (an additional configuration where the ramp and pressure shield are open, and the hatch is closed). The option includes additional control devices, signaling, and additional locks for safe cargo hatch operation. Time for Moving Components on the Ground (at t_{env} = 23° ± 3° C) is shown on figure 2.5.

	Aggregate	Time, sec		Aggregate	Time, sec
Opening	Pressure shield	3..5	Closing	Ramp	15...20
	Sash (Closed position) locks	not more than 3		Ramp (Closed position) locks	not more than 3
	Sash	15…18		Sash (Open position) locks	not more than 3
	Ramp (Closed position) locks	not more than 3		Sash	15...20
	Ramp	10...15		Sash (Closed position) locks	not more than 3
	Hatch	21..18		Pressure shield	3…5
				Hatch	20…31

Fig. 2.5. Time for Moving Components on the Ground.

Priority of control must be ensured: a) from the Cargo Hatch Control System (CHCS); b) from the controls of the backup channel over the controls of the main channel; c) from the controls in the crew cabin over the controls in the cargo cabin.

2.1.4 Stretcher connections

A structure designed to support stretchers in an airplane comprises an elongated stretcher-supporting frame intended to be positioned horizontally within the aircraft. Two leg assemblies are attached to the frame near its respective ends, and mechanisms connect these leg assemblies to the airplane floor [11]. Additionally, two straps are affixed to the frame on opposite sides, adjacent to each leg assembly, and means for anchoring the other ends of the straps to the airplane with the straps oriented diagonally downwardly to brace the frame and its supporting leg assemblies.

2.1.5 Galleys

Concurring to worldwide guidelines, the volume of the galleys ought to be approximately 0.1 cubic meter per traveler, so the volume of galley ought to be:

$$V_{galley} = 0.1 \cdot n_{passengers} = 0.1 \cdot 20 = 2\left(\mathrm{m}^2\right).$$

The total area of galley floor:

$$S_{galley} = V_{galley} \cdot H_{cab} = 2 \cdot 2.73 = 5.46\left(\mathrm{m}^2\right).$$

2.1.6 Lavatories

The inclusion of two lavatories within this certain type of aircraft might be confusing to those who consider a cargo plane, to begin with. Nevertheless, when it comes to the dispatch of injured soldiers and other personnel who work in the medical field, there are certain justified rationale behind this decision. First, they ensure meeting the medical needs. Special conditions should be met in order to give help to injured soldiers were being transported. This entails the need for frequent visits to the toilets to turning of bandages, washing of wounds and even personal hygiene.

Secondly, they should follow all the sanitary standards as this is important for everybody’s health. When it comes to transportation of persons with illnesses, especially in circumstances that may lead to the emergence of complications, failure to observe specific hygiene conditions is strictly prohibited. This includes cleaning of toilets and use of same for medical purposes when it is inevitable [12].

2.1.7 Layout and calculation of basic parameters of tail unit

One of the most crucial tasks in aerodynamic design is determining the placement of the tail unit. To ensure longitudinal stability during overloading, the center of gravity should be positioned ahead of the aircraft's focus. The degree of longitudinal stability determines by the distance between these points, relative to the mean aerodynamic chord of the wing:

$$m_x^{Cy} = \overline{x_T} - \overline{x_F} < 0,$$

where m_x^{Cy} – is the moment coefficient; x_T, x_F – center of gravity and focus coordinates. If $m_x^{Cy} = 0$, than the plane has the neutral longitudinal static stability, if than the plane is statically instable. In the normal aircraft scheme, focus of the combination wing – fuselage during the install of the tail unit of moved back.

An airplane is large and with swept wing, so in accordance with the airplane type, the next values were taken. TU span is related to the following dependence:

$$l_{HTU} = 0.32 \cdot l_w = 0.32 \cdot 35.83 = 11.46\,(\mathrm{m}).$$

A_{HTU}, A_{VTU} – coefficients of static moments:

$A_{HTU} = 0.6$;

$A_{VTU} = 0.066$.

$$\frac{L_{HTU}}{b_{MAC}} = \frac{10.79}{3.72} = 2.9\,.$$

The areas of vertical tail unit S_{VTU} and horizontal tail unit S_{HTU} are:

$$S_{HTU} = 0.207 \cdot S_w = 0.207 \cdot 120 = 24.8\,(\mathrm{m}^2),$$

$$S_{VTU} = 0.235 \cdot S_{wing} = 0.235 \cdot 120 = 25.3\,(\mathrm{m}^2).$$

L_{HTU} and L_{VTU} - arms of horizontal and vertical tail units respectively. That values depend on some factors. Firstly, their values are influenced by: the length of the tail and nose parts of the fuselage, sweptback and wing location, and in addition, from the circumstances of stability and control of the airplane. It can be determined from the formulas:

$$S_{HTU} = \frac{b_{MAC} \cdot S_w}{L_{HTU}} \cdot A_{HTU}\,,$$

$$L_{HTU} = \frac{b_{MAC} \cdot S_w}{S_{HTU}} \cdot A_{HTU} = \frac{3.72 \cdot 120 \cdot 0.6}{24.8} = 10.79\,(\mathrm{m}).$$

$$S_{VTU} = \frac{l_w \cdot S_w}{L_{VTU}} \cdot A_{VTU},$$

$$L_{VTU} = \frac{l_{wing} \cdot S_{wing}}{S_{VTU}} \cdot A_{VTU} = \frac{35.83 \cdot 120}{25.3} \cdot 0.066 = 11.2\,(\mathrm{m}).$$

Direction and elevator area determination:

Elevator area:

$$S_{el} = 0.312 \cdot S_{HTU} = 0.312 \cdot 24.8 = 7.74\,(\mathrm{m}^2).$$

Rudder area:

$$S_{rudder} = 0.21 \cdot S_{VTU} = 0.21 \cdot 25.3 = 5.3\,(\mathrm{m}^2).$$

For elevator and rudder, the next areas of aerodynamic balance were chosen:

$$S_{ab.rudder} = 0.22 \cdot S_{rudder} = 0.22 \cdot 5.3 = 1.17\,(\mathrm{m}^2).$$

$$S_{ab.el} = 0.25 \cdot S_{el} = 0.25 \cdot 7.74 = 1.94\,(\mathrm{m}^2).$$

h_{VTU} – height of the vertical part of the tail unit, is determined accordingly to the position of the engines. Engine is in the root part of the wing, so $h_{VTU} = 8.78$ m (according to the prototype An-178).

Sweep Angle is 30°. It is bigger than the wing sweptback angle on 3°. Vertical Tail Sweep Angle is 35°. It is bigger than the wing sweptback angle on 8°. TU sweptback is taken in that range, and not more than wing sweptback. It is provided to control the airplane in shock stall on the wing. The maximum speed of the new aircraft is less than the speed of sound, so the taper ratio for horizontal stabilizer $\eta_{HTU} = 2.25$ and vertical stabilizer $\eta_{VTU} = 1.74$.

Tail unit aspect ratios of stabilizers:

For transonic planes $\lambda_{VTU} = 0.644$;

$\lambda_{HTU} = 5.23$.

Determination of TU chords b_{tip}, b_{mac}, b_{root} for the horizontal stabilizer:

$$b_{tip} = \frac{2 \cdot S_{HTU}}{\eta_{HTU}} \cdot l_{HTU} = \frac{2 \cdot 24.8}{(2.2+1) \cdot 11.46} = 1.33\,(\mathrm{m}).$$

$$b_{root} = b_{tip} \cdot \eta_{HTU} = 3\left(\text{m}\right).$$

Mean aerodynamic chord was determined by geometrical method (fig. 2.6):

$$b_{MAC} = 2.25\left(\text{m}\right)$$

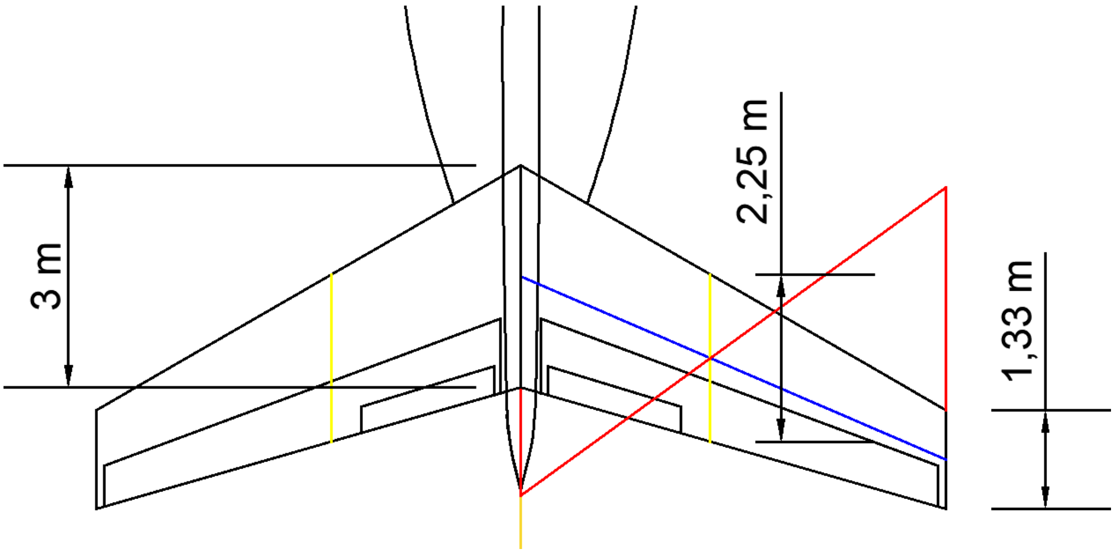


Fig. 2.6. Geometrical method of determination of the mean aerodynamic chord.

TU chords b_{tip}, b_{MAC}, b_{root} for the vertical stabilizer are chosen according to the prototype: $b_{tip} = 4.57$ m, $b_{MAC} = 6.43$ m, $b_{root} = 7.98$ m.

$$b_{root} = 7.98\left(\text{m}\right);$$

$$b_{tip} = 4.57\left(\text{m}\right);$$

$$b_{MAC} = 6.43\left(\text{m}\right).$$

2.1.8. Landing gear design

Landing gear is another of the decisive elements of an aircraft, the design of which can influence safety. Among the variants used in the new aircraft, the most common is the tricycle or “nose-gear” configuration of the landing gear. These wheels are positioned rearward of the balance point or center gravity and is substantially closer to it than the forward gear while supporting a major share of the airplanes weight and load; therefore, referred to as the main wheel. Two must be located at equal distances from the cg along the x-axis and the same distance in the y-axis, in which it should also share the same load as the other; in this manner, both would experience the same stresses. This feature provides the most gear as the closest to the cg while forward gear is much farther and carries a much lighter load. It is known that 80-90% of load belongs to the main gear, therefore the nose gear, takes 10-20%. The main geometrical parametes for the LG are wheel base and wheel track. The connection between the aircraft and landing gear significantly affects various design requirements, like cost, stability on the groung, weight, landing and take-off performances. All struts of the wheels are attached to the fuselage of the new aircraft. The new aircraft will have the undercarriage that is fully retracted inside the fuselage.

The primary functions of the landing gear are as follows: a) to support the aircraft during ground operations including loading, unloading, and taxiing; b) to provide free movement and maneuverability during taxiing operations; c) to have a spacing between the aircraft wing and the body while the aircraft is on the ground in order to steer clear of damage due to contact with the ground; d) to reduce the impact on an aircraft during landing; e) to allow for take off by providing the least coefficient of friction.

Considering static and dynamic load requirements is essential to guarantee that the landing gear can handle the various forces exerted on it during different phases of flight. This includes the weight of the aircraft, as well as external factors like turbulence. Meeting low-cost requirements without compromising safety and efficiency is a challenging but essential aspect of the overall design process. Additionally, designing an effective landing gear system involves addressing three more crucial aspects: low weight, maintainability, and manufacturability.

By the way of the prototype taking into consideration it is necessary to point that landing gear wheel base is B = 11,58 m. Large value has airplane with the engine on the wing. Assuming the value of the wheel base, the distance from the center of gravity to the main LG is

$$B_m = 0.744\,(\mathrm{m}).$$

The distance between the cg and the nose landig gear:

$$B_n = B - B_m = 11.58 - 0.774 = 10.836\,(\mathrm{m}).$$

In accordance with the geometrical characteristics of the An-178, the wheel track of the new aircraft will be:

$$T = 4.2\,(\mathrm{m}) \le 12\,(\mathrm{m}).$$

On a condition of the prevention of the side nose-over it is necessary to have the value T more than 2H, where H is the distance between runaway and the center of gravity. In order to select tires for the main and nose gear it is required to determine the loads on these tires [13]. Selecting the wheels of the landing gear depends on the size of the run loading from the take-off weight; and for the front support, the dynamic load was also taken into account.

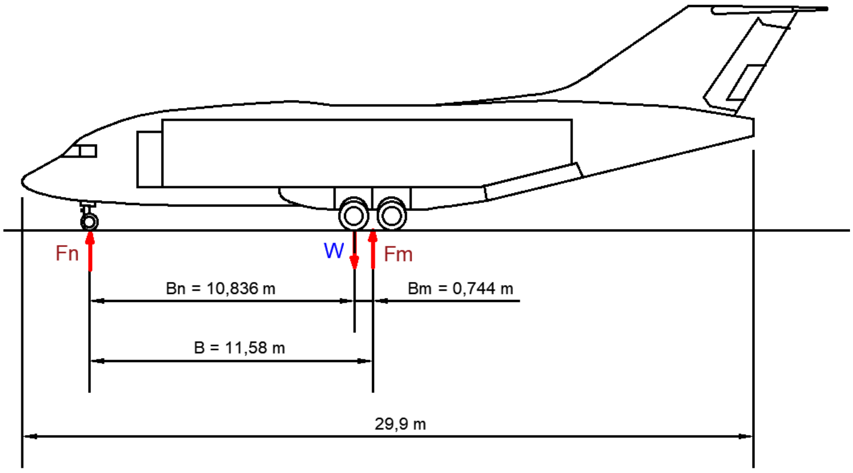


Fig. 2.7. The basic parameters, layout of landing gear and loading.

$$\sum F_z = 0 \rightarrow F_n + F_m = W.$$

$$\sum M_0 = 0 \rightarrow F_n \cdot B + W \cdot F_m = 0.$$

From these equilibrium equations we take F_n and F_m:

$$F_n = \frac{B_m}{B} \cdot W = \frac{0.744}{11.58} \cdot 67453 \cdot 9.8 = 42471\,(N) = 9548\,(lbs).$$

$$F_m = \frac{B_n}{B} \cdot W = \frac{10.836}{11.58} \cdot 67453 \cdot 9.8 = 618587\left(N\right) = 139060\left(lbs\right).$$

$$F_{main} = \frac{\left(B - B_m\right) \cdot m_0 \cdot 9.81}{B \cdot n \cdot z} = \frac{\left(11.58 - 0.744\right) \cdot 67453 \cdot 9.81}{11.58 \cdot 4 \cdot 1} = 154800\left(N\right) = 34800\left(lbs\right).$$

$$F_{nose} = \frac{B_m \cdot m_0 \cdot g \cdot K_g}{B \cdot z} = \frac{0.744 \cdot 67453 \cdot 9.81 \cdot 1.7}{11.58 \cdot 2} = 36137\left(N\right) = 8124\left(lbs\right),$$

where n and z – is the quantity of the supports and wheels on the one leg; K_g – dynamics coefficient; m_0 – maximum take-off mass, kg.

According to the initial data of designing aircraft the speed for take-off for the aircraft is 253.1 km/hour, so we could find the tires in the Goodyear catalogue.

Main tires characteristics are shawn on figure 2.8.

Nose landing gear										
Size	Construction			Service rating				Tread design/Trade mark	Part №	Weight
	Ply rating	TT or TL	Rated speed	Rated load	Rated inflation	Maxmum braking	Maximum bottoming load			
25.5 x 8.75-10	14	TL	190 mph	8500 lbs	101 psi	12750 lbs	22950 lbs	Rib	№259K48G1	33.5 lbs
Main landing gear										
Size	Construction			Service rating				Tread design/Trade mark	Part №	Weight
	Ply rating	TT or TL	Rated speed	Rated load	Rated inflation	Maxmum braking	Maximum bottoming load			
H40 x 14.5-19	26	TL	225 mph	36800 lbs	220 psi	53360 lbs	99360 lbs	Flight leader	№419K62-3	150.4 lbs

Fig. 2.8. Characteristics of the tires for nose and main landing gear.

2.2 Determination of the aircraft center of gravity position

Centering is a term used to refer to the distance between the main aerodynamic chords and the center of an aircraft. This position may vary during a flight depending on the initial loading and the subsequent changes in the load distribution or shifting of goods within a plane, movements of cargo within the aircraft.

The positioning of the aircraft's center of gravity is crucial for maintaining balance, stability, and controllability, and therefore strict limits must be adhered to. Calculating centering involves determining the mass of key structural components and devices. Static longitudinal stability relies on the relationship between the aircraft's center of mass and its focal points. When the center of mass is closer to the nose of the aircraft, greater longitudinal stability is achieved.

2.2.1 Centering of the equipped wing determination

The information about the total mass of the equipped wing is contained in its trim sheet, which includes data on the mass of the structure, the mass of the installed equipment, and the fuel volumes. Both the main landing gear and the front gear are considered part of the equipped wing's mass, regardless of whether they are installed on the wing or the fuselage. The mass register lists the names of the objects, the coordinates of their center of gravity and masses of that objects. Table 2.1 lists approximate mass values for various objects for aircraft with engines located under the wing. The origin of the coordinates is determined by projecting the nose point of the mean aerodynamic chord (MAC) onto the XOY surface. Positive coordinate values are assigned to the rear part of the aircraft. Specific computational formulas are used to determine the coordinates of the center of power of the equipped wing.

$$X'_w = \frac{\sum m'_i \cdot x_i}{\sum m'_i},$$

where $m_i^{'}$ – mass of a unit, kg; $X_w^{'}$ – center of mass for equipped wing, m; x_i – center of mass of the unit, m.

Table 2.1

List of equipped wing masses

#	Object name	Mass		Center of gravity coordinates, m	Moment of mass, kg·m
		Units	Total mass, kg		
1	2	3	4	5	6
1	Wing (structure)	0.139	9367.198	1.6	14983.77
2	Fuel system	0.004	236.086	1.6	377.642
3	Flight control system, 30%	0.002	131.533	2.232	293.582
4	Electrical equipment, 10%	0.002	135.581	0.372	50.436
5	Anti-ice system, 40%	0.006	431.699	0.372	160.592
6	Hydraulic system, 70%	0.012	826.299	2.232	1844.300
7	Power plant	0.092	10711	-2.191	-23467.42
	Equipped wing without landing gear and fuel	**0.2088**	**24309**	**0.271**	**6578.72**
8	Nose landing gear	0.005	570	-13.172	-7514.20

Ending of the table 2.1

1	2	3	4	5	6
9	Main landing gear	0.035	4086	2.8	11441.95
10	Fuel for flight	0.308	35858	1.575	54476.31
	Totally equipped wing	**0.592**	**68899**	**1.08**	**74470.17**

2.2.2 Determination of the centering of the equipped fuselage

The projection of the fuselage nose onto the horizontal axis is selected as the coordinate origin. The construction part of the fuselage is indicated for the X-axis. Table 2.2 provides an illustrative list of objects for the aircraft with engines mounted beneath the wing.

Formulas are employed to determine the Center of Gravity (CG) coordinates for the Front Engine Fuselage (FEF).

$$X'_f = \frac{\sum m'_i \cdot x_i}{\sum m'_i},$$

where, x_i – center of mass of the unit, m; X'_f – center of mass for equipped fuselage, m; m'_i – mass of a unit, kg.

Table 2.2

List of equipped fuselage masses

#	Object name	Mass		Center of gravity coordinates, m	Moment of mass, kg·m
		Units	Total mass, kg		
1	2	3	4	5	6
1	Fuselage	0.130	8735.84	14.95	130600.78
2	Horizontal tail	0.017	1121.07	30.236	33896.64
3	Vertical tail	0.019	1272.84	27	34366.63
4	Radar	0.006	391.23	0.53	207.35
5	Radio equipment	0.004	290.05	0.53	153.73
6	Instrument panel	0.010	681.28	1.8	1226.30
7	Aero navigation equipment	0.009	586.84	1.8	1056.31
8	Flight control system, 70%	0.005	306.91	14.95	4588.32
9	Hydraulic system, 30%	0.005	354.13	20.93	7411.90
10	Electrical equipment, 90%	0.018	1220.22	14.95	18242.36
11	Not typical equipment	0.001	39.80	12	477.57
2	Lining and insulation	0.007	465.43	14.95	6958.11
13	Anti ice system, 20%	0.003	215.85	23.92	5163.12
14	Airconditioning system, 40%	0.006	431.70	14.95	6453.90
15	Medical equipment	0.019	1267.94	14.95	18955.75
16	Furnishing (buffet and lavatory)	0.007	500.00	7	3500
17	Operational items	0.013	900.24	5	4501.22

Ending of the table 2.2

1	2	3	4	5	6
18	additional eguipment	0.001	39.61	5	198.06
	Equipped fuselage without commercial load	0.279	18820.97	14.77	277958.05
19	Crew seats	0.002	150	2.55	382.5
20	Payload	0.297	20000	14.95	299000
	Totally equipped fuselage	0.578	38970.97	14.81	577340.55

2.2.3 Calculation of center of gravity positioning variants

Once, the Center of Gravity (C.G.) have been set up for the completely prepared fuselage and prepared wing, the moment equilibrium equation was defined concerning the nose of the fuselage:

$$m_f \cdot X'_f + m_w (X_{MAC} + X'_w) = m_0 (X_{MAC} + C) .$$

where m_f – mass of fully equipped fuselage, kg; m_0 – aircraft take-off mass, kg; C is the distance between MAC leading edge and the center of gravity point, m_w – mass of fully equipped wing, kg;

Relative to the fuselage, MAC leading edge position of the wing was determined from here, so X_{MAC} value is:

$$X_{MAC} = \frac{m_f \cdot X'_f + m_w \cdot X'_w - m_0 \cdot C \cdot b_{MAC}}{m_0 - m_w} ,$$

$$X_{MAC} = \frac{38970.97 \cdot 14.81 + 28482.029 \cdot 0.238 - 67453 \cdot 0.26 \cdot 3.72}{67453 - 28482.029} = 13.31 (\mathrm{m}),$$

where m_f – mass of fully equipped fuselage, kg; m_0 – aircraft takeoff mass, kg; C is the distance between MAC leading edge and the center of gravity point; m_w –mass of fully equipped wing, kg.

For the high wing airplane:

$$C = (0.23...0.32) \cdot B_{MAC} = 0.26 \cdot 3.72 = 0.9672 .$$

In the table 2.3, the list of mass objects for center of gravity variations calculation is given and in the table 2.4 the center of gravity calculation alternatives is given completed on the base of both past tables.

Table 2.3

Calculation of center of gravity position variants

#	Object name	Mass, kg	Center of gravity coordinates, m	Moment of mass, kg·m
1	2	3	4	5
1	Equipped wing (without fuel and landing gear)	17291.58	13.19	228031.53
2	Nose landing gear (extended)	614.36	2.74	1686.10
3	Main landing gear (extended)	2457.45	14.32	35201.65
4	Fuel reserve	2395.93	14.91	35733.09
5	Fuel for flight	5722.71	14.91	85348.97
6	Equipped fuselage (without payload)	18820.97	14.77	277958.05
7	Payload	20000	14.95	299000
8	Crew	150	2.55	382.5
9	Nose landing gear (retrected)	614.36	1.74	1071.74
10	Main landing gear (retrected)	2457.45	14.32	35201.65

Table 2.4

Aircraft's center of gravity position variants

#	Variant of loading	Mass, kg	Moment of mass, kg·m	Center of gravity coordinates, m	Centering, %
1	2	3	4	5	6
1	Take-off mass (landing gear extended)	67453	963341.89	14,28	26
2	Take-off mass (landing gear retracted)	67453	962727.53	14.27	25.76
3	Landing variant (landing gear extended)	61730.29	877992.92	14.22	24.42
4	Ferry version (without payload. max fuel. LG retracted)	47453	663727.53	13.99	18.08
5	Parking version (without payload. without fuel foe flight. LG extended)	41580.29	578610.42	13.92	16.16

Conclusions to the project part

In this part, we calculated the centering of the designed aircraft and determined its main geometric dimensions. During the calculations, we considered the operational purpose, the planned number of patients, medical staff, and medical equipment, as well as the different flight regimes and the landing and take-off conditions. The center of gravity position can change relative to the nose of the aircraft.

During take-off with the maximum take-off mass, the center of gravity will be 26 meters from the nose of the aircraft if the landing gears are extended. But, if they are retracted, the distance is 25.76 m. In ferry version, the distance will be 18.08 m. Without payload, without fuel for flight and if the landing gears are extended, the distance from the nose of the aircraft and center of gravity is 16.16 m.

3. STRETCHER ESCALATOR

3.1 Introduction

This part relates to the design of an escalator which would allow patient stretchers to remain flat during loading and at all other stages of transportation within the cabin. The proposed enhancement is suitable for application on short-haul aircrafts with a take off weight of up to 67.5 tons but can also be used for other transport category aircraft that are designed to be loaded from ramps. These are stretchers escalators, which have non-slip surface finish, and both movable and immovable barriers for the safety of the users. Adjustable fences have been incorporated in the lift and its operation is done using continuous-press buttons. Electric lift control can be managed via lift or winch-type electrical remotes.

The operational principle of the device is as follows: 1) The call button must be pressed by the member of the medical staff; 2) The mechanical platform is in motion; 3) The fences are closed when the patient on the stretcher is placed on the platform. In this process, if this step is missed, the lift does not work; 4) One of the members of the medical staff has to press the start button while the patient on the stretcher is taken to the required area in the cabin.

The noise level of the system is not over 63 dB. This inclined lift can be mounted using reinforced supports. In their non-use, the platforms of these inclined stretcher lifts can be folded to allow for other space when not in use without hindering other operations of the aircraft or endangering the lives of the patient and other personnel.

The main elements of the escalator are painted with industrial paints such as Akzo Nobel or Alpina which provide good anti-corrosive properties [15]. These are produced in Netherlands and Germany. The frame of the platform is constructed of Ukrainian steel and complies with all the norms and requirements currently in force.

3.2 Personnel responsibilities and requirements for medical evacuation

Aero-medical evacuation is a rather perspective and innovative direction of intensive medicine. It is also known as aeromedical transport or air ambulances. Aeromedical evacuation was also a form of improvement with regard to assisting individuals [16]. When a patient gets medical help of the right type and quality, the prognosis for his or her recovery appears to be much better and, at times, might be a matter of life and death. Another feature of the aircraft is the main landing gear kneeling system meant to facilitate in the loading of the vehicles into the main cargo compartment. Both the transportation company that will be using the new aircraft, Other Airlines with fixed schedule flights, that will be using the new type of aircraft will be required to interact with humanitarian organizations or consulting companies such as Medical Expert International Company. Air Transport Critical Care Teams contains: Cardiovascular laboratory technician, anesthesist, intensivist, a nurse who specializes in critical patients' care. In terms of staff duties, personnel are responsible for several key tasks: a) transferring the patient to the airport; b) ensuring the appropriate clearance to move the patient on to the aircraft; c) helping the patient to board the aircraft; d) monitoring the patient's condition during the flight; e) to help the patient disembark upon arrival at the airport and arranging for further transport; f) the movement of patients in a supine position by air is not without its challenges, which are handled by the medical team [17]. Therefore, the use of a special escalator for the stretchers is important in the loading process.

The reason for the existence of sanaviation is when there is another means of transport required depending on the levels of patients. If the delayted transport lead to the deterioration of the person's condition or critical situation, providing a fast and effective solution should be taken into consideration. Furthermore, air-ambulance transportation should also be considered if the clinic is quite far away from the hospital.

It is as follows: limb amputations, scars, combat injuries, acute trauma, coma resulting from various causes, post-traumatic paralysis, central nervous system diseases, spinal injuries, including cervical, pelvic trauma, aneurysm of the aorta, septic shock, intrabdominal hemorrhage, and purulent-inflammatory soft tissue diseases [17].

The abbreviation of the term “Medical evacuation” is used as “medevac” or “medivac”. It means taking the injured persons from the war fields, the car accident victims to the hospitals, or the patients in the rural health care centers who need urgent medical attention. Fixed-wing aircraft can move patients within a particular theater of operation (intratheater) or between two or more theaters (intertheater). There are a lot of requirements for medical evacuation. Firstly, surgical equipment and specialist physicians are necessary for medical evacuation. What is more, to withstand appropriate situations of transportation and the duration of the trip, the patient’s condition must be stable enough. Also, the patient’s airway and breathing should tolerate transportation. Medical equipment like intravenous lines, drains, and patient tubes must be patent and securely fastened. If a patient has a risk of chest trauma, prophylactic placement of a pleural drainage tube before extended medical air transport is considered. Heimlich valves should be functioned well in pleural drainage tubes. Moreover, the following requirement must be met: foley catheters and nasogastric tubes should remain in place and can be drained. If the whether is cold or there is postoperative hypothermia during air transport, blankets and thermal wraps should be available. Three straps are needed for reliable fiaation of patient. Personal goods and all documentation about his/her condition should be transported with the patient. As for the change of the flight altitude, the volume of air bubbles in fluid doubles at 18,000 feet (5,485 meters) above sea level, so if the aircraft allows, cabin pressure can be maintained at a lower level. But, this decision significantly increases flight time and fuel consumption. If there are an eye injury, presence of air in body cavities, or severe lung disease should be considered the cabin pressure limitations. Patients, especially those with extensive burns or a risk of mucosal obstruction, require additional humidity. Cabin pressure should be maintained at the same level as the landing site for decompression sickness and arterial gas embolism. During transportation 100% oxygen must be provided (use aviation masks if possible). Three oxygen cylinders should be inside the cabin for each patient, if flight is not more than

1 hour. What is more, chest tube should be installed on the aircraft in all cases of pneumothorax. Prior to the transport of the patient to the plane the endotracheal tube should be connected to a Heimlich valve or other re-expansion system that is approved. In cases where there are other forms of splints other than the pneumatic splints, they should be discouraged. Before using this inflatable splint during a flight, be aware that air expands at higher altitude thus should regulate the pneumatic splints properly during the flight [7].

As a fact, oxygen partial pressure decreases with altitude. At sea level, oxygen saturation in a healthy person is 98-100% at 8,000 feet (2,438 meters), it decreases to 90% but can be corrected to 98-100% using oxygen at a rate of 2 liters per minute.

If we consider the requirements, norms, and regulations that may apply to a new aircraft, it could be regulated by organizations such as the Federal Aviation Administration (FAA) in the USA, the European Union Aviation Safety Agency (EASA), or the State Aviation Service of Ukraine. The FARs are developed by the FAA, while the CSs are official documents created by aviation organizations like EASA. There are numerous sets of aviation regulatory documents that could apply to a new aircraft; here are some of them:

1) CS 25.333 – "Flight Manoeuvring Envelope" specifies the strength requirements for aircraft during maneuvers [10];

2) CS 25.943 – "Negative Acceleration". Under negative accelerations (e.g., during braking), the aircraft must not experience hazardous malfunctions of the engine, auxiliary power unit, or any components or systems associated with the APU or powerplant. This requirement applies within the maneuvering envelope defined in CS 25.333 [10];

3) CS 25.801 – The design of the aircraft must account for the possibility of an emergency water landing. Practical measures must be taken to minimize the likelihood of immediate harm to passengers or the inability to rescue them [10];

4) Guide to Hygiene and Sanitation in Aviation Third Edition (World Health Organization, ICAO): a) Guideline 3.4: aircraft are kept in a sanitary condition at all times; b) Roles and responsibilities (point 1.3): International organizations and

aircraft and airport operators play a critical role in ensuring the health of passengers and crew. Monitoring the quality of drinking water, food, regular cleaning, disinfection, waste disposal and management of on-board water systems require cooperation between airlines, airports and ground services [12];

5) 14 CFR Part 25 – Airworthiness Standards: Transport Category Airplanes (FAR-25) [14].

3.3 Detailed description of the phases of loading equipment, boarding personnel, and patients onto the medical aircraft

The aircraft is features side doors for convenient access and it is equipped with a ramp for easy loading and unloading of patients and equipment. A unique feature of this aircraft is the escalator installed along the interior wall of the fuselage, which is used for transporting patients along the cabin. The cabin is 13 meters in length and 2.73 meters in width. Also there is a special room, for the most injured patient, that organizing all necessary equipment. Inside, there are 10 seats for medical personnel, ensuring enough specialists to care for patients during the flight. For patients, there are 7 adjustable beds for maximum comfort and access to medical equipment. The aircraft is designed with the needs for the efficient and safe transport of patients over long distances. The escalator simplifies the process of moving patients on and off the aircraft, making loading and unloading quicker and more convenient. Thus, this aircraft provides all the necessary conditions for delivering high-level medical care during flight. Within 85 minutes, the aircraft with all necessary equipment, medical personal and patients can be ready for takeoff, ensuring all necessary conditions for their transportation and medical care during the flight. The first activity that is involved in the loading phase is the aircraft preparation where the aircraft is loaded for 10 minutes. It involves strict aircraft inspection by the technical personnel of the plane’s interior and exterior part, fuel and hygiene. Moreover, their work is also associated with the arrangement and distribution of the interior space of the aircraft in mind for easy access to patients and equipment. The next step is the time taken to load the equipments which take about 20 minutes. It involves loading huge equipment through a ramp and then putting the equipment within the plane. Arranging all used technical medical tools returning them to their initial positions for use when required. The third phase is boarding of medical personnel (10 minutes): a) Medical staff from the aircraft cabin door seat (5 minutes); b) Medical staff to check equipment and space for accepting patients; The fourth stage is the patient loading (30 minutes): a) Patient preparation for transportation (5 minutes per patient): The medical personnel then assess each patient, and attach any medical equipment that may be required. b) Transferring the patient on stretchers and ascending the ramp using the escalator (5 minutes per patient): The atop patient on the stretcher is hoisted up onto the ramp and locked on to the escalator. The patient is lifted by the escalator up the ramp and then slides the patient along the wall of the fuselage, and gets to the bed place. The same process is followed for each of the 7 patients. The final stage is securing patients and equipment (10 minutes): Layout: a) The stretchers with the patient comprises of firmly anchoring the same. Absolutely and without fail – 5 minutes. In this context, then, the patients are attached to the required gear (oxygen, monitoring machines, and other requirements). b) The final inspection of the readiness of the aircraft for flight, check and placing some of items and ensuring the status of the patients (5 min).

3.4 Advantages of the escalator

The escalator is useful in the lifting of patients up the ramp without strain and this will help avoid cases of injuries among the patient and the personnel if it is. It reduces the physical stress involved and helps complete the loading process faster since medical personnel do not have to assume the responsibility of lifting the patients manually. The patient transport is more seamless, which is particularly important for stable as well as unstable and acutely ill patients as it reduces chances of their condition deteriorating. The escalator provides a better solution for loading the patients and it also provide more safety and laborsaving for the medical staffs. It also has the advantage of minimizing health risks related to patient and staff and is fairly crucial particularly in situations such as medical evacuation and transport of patients with certain medical conditions.

3.5 Calculations of the main parameters for reducer, accumulator and motor

For the escalator, it was considered to apply a motor reducer with an output shaft diameter of 0.01 m and nominal rotation frequency at 71 rpm gear motor reducer worm type МЧ-40-71 [18]. Steel is used as the material of shaft with allowable stress (σ) = 80 MPa (80×10^6 Pa). Where the force *F* (*N*) is due to the weight of the load which can be calculated as:

$$F = m \cdot g = 250 \cdot 9.81 = 2452.5\,(N),$$

where *m* – is the mass of the load (250 kg). *g* – is the acceleration due to gravity (approximately 9.81 m/s^2).

The power *P* needed by the lift can be calculated using the formula:

$$P = F \cdot v = 2451.5 \cdot 0.1 = 245.25\,(W),$$

where, F – the force exerted by the lift (equal to the weight it lifts). *v* – the velocity of the escalator 6 m/min (0.1 m/s).

To find the energy required E, we need to consider how long the escalator will be in operation. Assuming the escalator operates for 1 hour, the energy required is:

$$E = P \cdot t = 245.25 \cdot 1 = 245.25\,(Wh).$$

Battery capacity in ampere-hours (Ah) can be found using the formula:

$$Capacity(Ah) = \frac{E}{V} = \frac{245.25}{28} = 8.76\,(Ah),$$

where, *V* – the voltage of the battery (28 V).

Let's convert 71 rpm to m/s:

$$n \cdot \frac{2 \cdot \pi \cdot r}{60} = 0.557\,(m/s).$$

Since the escalator moves at a speed of 0.1 m/s, we can determine the gear ratio:

$$i = \frac{0.557}{0.1} = 5.6.$$

Therefore, a gear with 62 teeth will be attached to the motor-reducer shaft. It will drive two adjacent gears with 11 teeth each, which are symmetrically positioned relative to the main gear (fig. 3.1) [19].

$$i = \frac{z_2}{z_1} = \frac{62}{11} = 5.6.$$

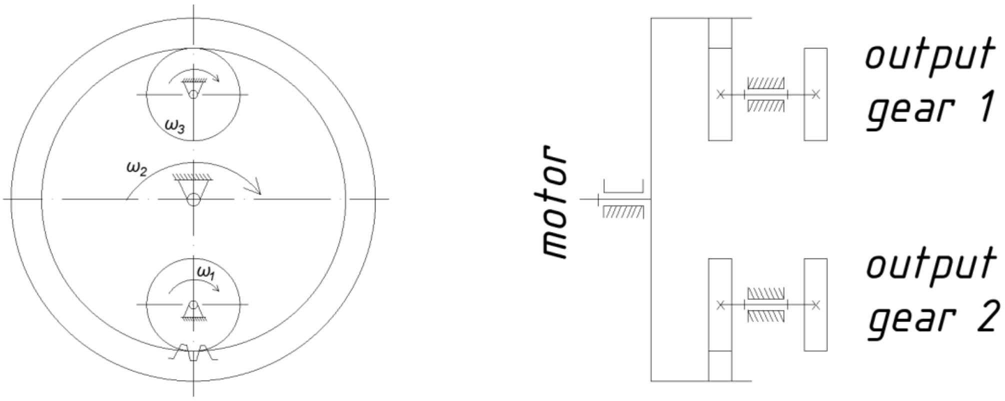


Fig. 3.1. Compaund gearings.

The addendum diameter of the output gear was chosen – 15 cm. So, let`s find a module:

$$m = \frac{d_a}{z+2} = \frac{15}{11+2} = 1.15.$$

Diameter of the dedendum circle is:

$$d_f = m \cdot (z - 2.5) = 1.15 \cdot (11 - 2.5) = 9.8\,(cm).$$

Pitch:

$$p = m \cdot \pi = 1.15 \cdot \pi = 3.6\,(cm).$$

Diameter of the nominal pitch circle:

$$d_{nom} = m \cdot z = 1.15 \cdot \pi = 12.7\left(cm\right).$$

3.6 Calculations of the stresses acting on the main structural elements of the escalator for stretchers

The weight of the escalator together with the patient and the stretcher is 250 kg. The total load on the Oy axis, taking into account the safety factor, is 375 kgf:

$$P_y^P = G \cdot n_{safety} = 250 \cdot 1.5 = 375\left(kgf\right) = 3677.5\left(N\right).$$

An escalator moves along the cabin of the aircraft by using of one pair of gears, that are attached to the motor with gear transmission, and two pairs of rollers. The direction of movement of the rollers occurs due to two rails in the form of channels, which are located at the top and bottom of the escalator. The gears move along a beam that is a thin-walled closed loop. The teeth for moving the gears are fixed to the beam using special fasteners. In turn, this beam is fixed using brackets on racks installed along the cabin with a gap of 1200 mm.

From the rear side, the escalator will look like in Figure 3.2.

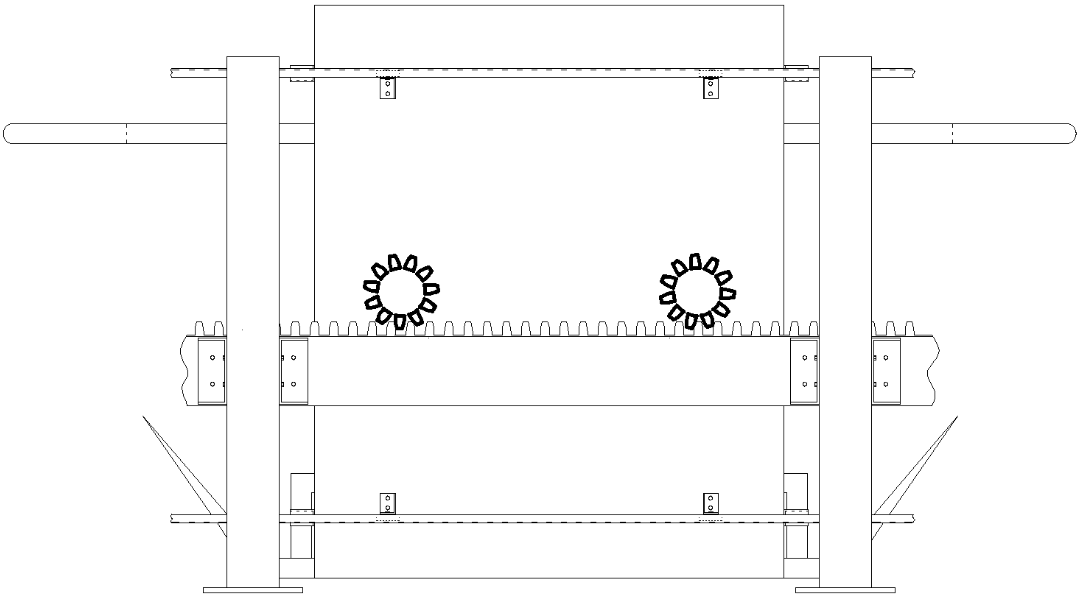


Fig. 3.2. Thin-walled beam connection.

The load will be distributed among some the elements of the escalator structure: a) two gears and their axes; b) two pairs of rollers and their axes; c) guide rails; d) beam with a closed contour on which the teeth will be mounted; e) brackets. f) pin for securing the escalator during flight; g) mounting bolts. Loads were calculated for both operational and emergency landing conditions. Assuming that the internal elements of the control box are evenly distributed, the center of gravity relative to the gear is located at a distance of 40 cm and 58.1 cm from the Oz and Oy axes, respectively. The force P_y will generate a moment about the Ox axis.

$$M_x^P = P_y^P \cdot 40 = 250 \cdot 40 = 10000\left(kgf \cdot cm\right) = 980665\left(\mathrm{N} \cdot \mathrm{mm}\right).$$

Rollers are attached to the control box of the escalator using brackets and bolts. The rollers move along rails attached to the control box of the escalator from the top and bottom. The distance between the rollers along the *Oy* axis is *90 cm*, as shown in figure 3.3.

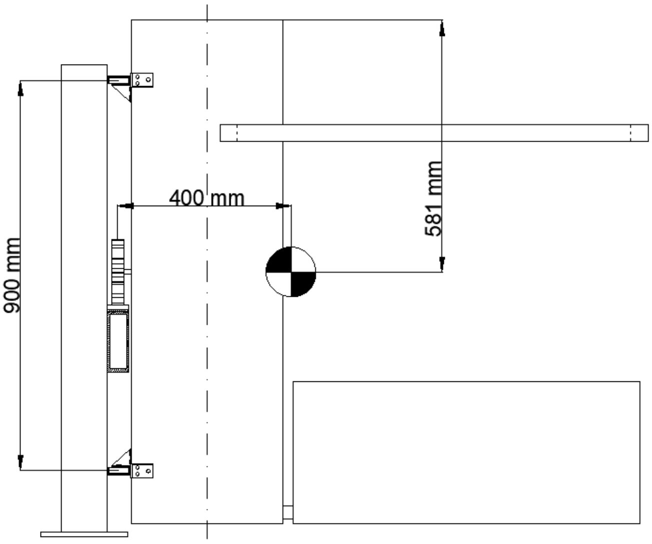
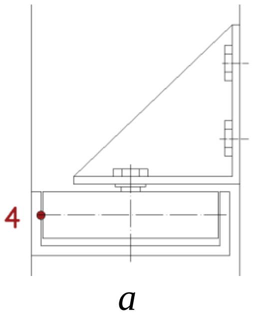


Fig. 3.3. Distances from the center of mass and between rollers.

In Figure 3.4 (a, b) the points where the main load acts are shawn. The moment generated by the escalator relative to the Ox axis is perceived by the rollers at points 3 and 4.



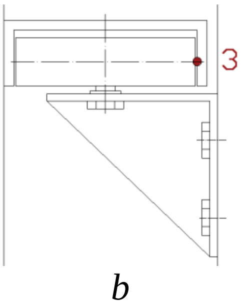


Fig. 3.4. The moment generated by the escalator:
a – Loaded point 4; *b* – Loaded point 3.

Figure 3.5 depicts the load on the gear during operation.

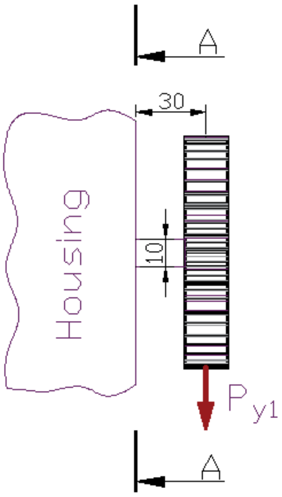


Fig. 3.5 Gear loading.

Since the motor inside the control box will drive two gears, the load on one gear will be:

$$P_{y1}^{P}=P_{y2}^{P}=\frac{P_{y}^{P}}{2}=\frac{375}{2}=187.5\,(kgf)=1838.7\,(N).$$

Let's consider section A-A to find the forces and stresses in it. The diameter of the axis on which the gear is held is 10 mm. First, we need to find the area and the section modulus about the neutral axis of its cross-section.

Cross- section area:

$$F=\pi\cdot r^2=3.14\cdot 0.5^2=0.7854\left(cm^2\right)=78.54\left(mm^2\right).$$

Section modulus:

$$W=\frac{\pi\cdot D^3}{32}=\frac{\pi\cdot 1^3}{32}=0.0982\left(cm^3\right)=98.2\left(mm^3\right).$$

The force in the cross-section A-A:

$$Q^P=P_{y1}^P=187.5\left(kgf\right)=1838.7\left(N\right).$$

$$M^P=P_{y1}^P\cdot 3=187.5\cdot 3=562.5\left(kgf\cdot cm\right)=55162.4\left(\mathrm{N}\cdot\mathrm{mm}\right).$$

Along the axis of rotation of the gear, there are normal and shear stresses.

$$\tau^P=\frac{Q^P}{F}=\frac{187.5}{0.7854}=238.7\left(kgf\,/\,cm^2\right)=23.4\left(N\,/\,mm^2\right).$$

$$\sigma^P=\frac{M^P}{W}=\frac{562.5}{0.0982}=5730\left(kgf\,/\,cm^2\right)=562\left(N\,/\,mm^2\right).$$

Using the fourth theory of strength from Huber-Mises-Hencky, we can calculate the equivalent stress.

$$\sigma_{eq}^P=\sqrt{\sigma^2+4\cdot\tau^2}=\sqrt{5730^2+4\cdot 238.7^2}=5750\left(kgf\,/\,cm^2\right)=563.9\left(N\,/\,mm^2\right).$$

The safety factor, considering that the axis is made of steel 30ХГСА, is calculated as:

$$\eta=\frac{\sigma_{ult.str}}{\sigma_{equivalent.str}}=\frac{11000}{5730}=1.9\,.$$

Therefore, we can conclude that the axis can withstand the specified load. By using an ANSYS program equivalent stress and total deformation were illustrated and investigated (fig. 3.6 – 3.7).

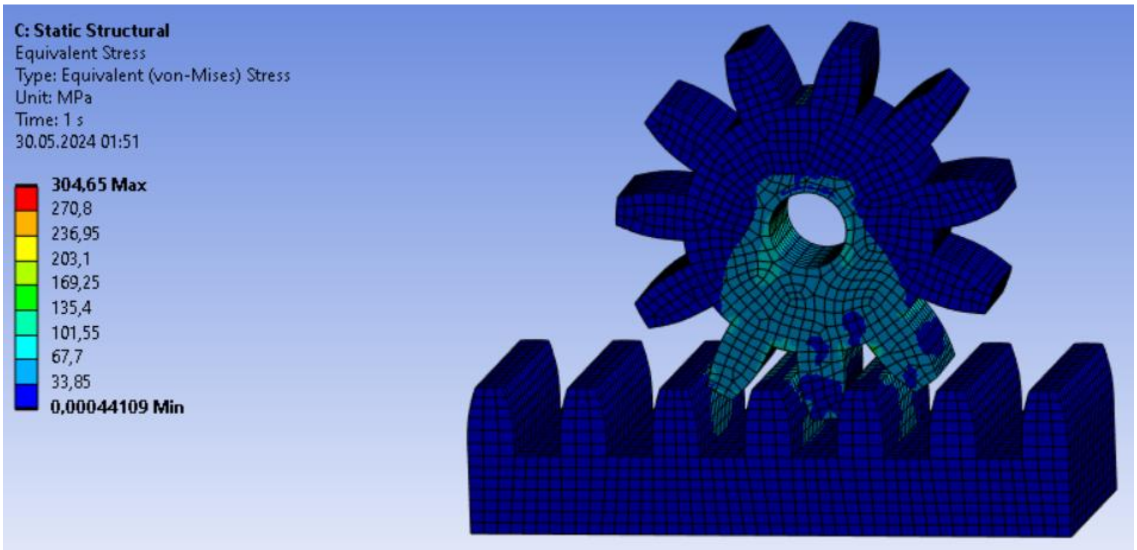


Fig. 3.6. Equivalent stress.

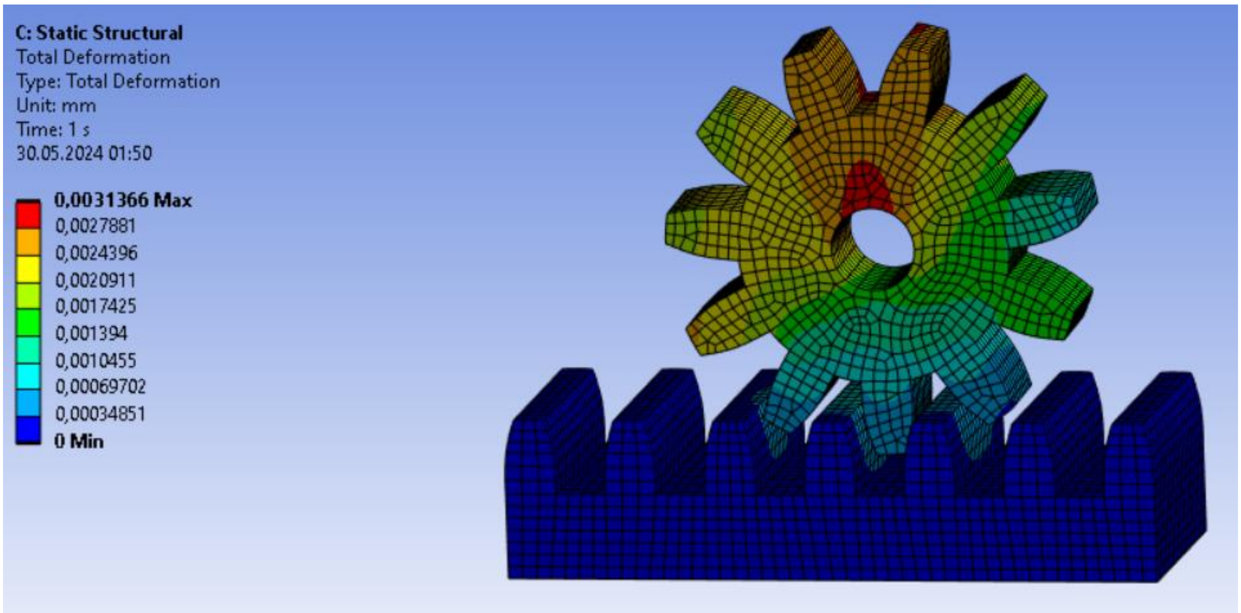


Fig. 3.7. Total deformation.

To calculate the loads acting on all rollers during operation, the load on one roller was considered:

$$P^P_{z31} = P^P_{z32} = -P^P_{z41} = -P^P_{z42} = \frac{1}{2}\cdot\frac{M^P_x}{90} = \frac{1}{2}\cdot\frac{10000}{90} = 56\left(kgf\right) = 549\left(N\right).$$

Moment from P^P_{z31}:

$$M^P = P^P_{z31} \cdot L = 56 \cdot 0.82 = 46\,(kgf \cdot cm) = 4511\,(\mathrm{N} \cdot \mathrm{mm}).$$

Let's consider section B-B, which is closest to the axis of rotation of the roller, to find the stress safety factor (fig. 3.8).

$$F = 0.96\,(cm^2) = 96\,(mm^2);$$
$$W_{up} = 0.682\,(cm^3) = 682\,(mm^3);$$
$$W_{down} = 0.212\,(cm^3) = 212\,(mm^3).$$

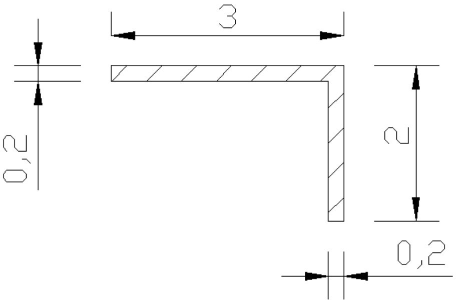


Fig. 3.8. Cross-section B-B.

Stresses in cross-section:

$$\sigma^P = \frac{M^P}{W_{down}} = \frac{46}{0.212} = 217\,(kgf\,/\,cm^2) = 21.3\,(N\,/\,mm^2).$$

The safety factor, considering that the bracket is made of aluminum, is calculated as:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{4100}{217} = 18.9.$$

Gear wheels move along the rail along the Ox axis. The teeth will be attached to the beam using bolts with a diameter of 5 mm, made of steel 30ХГСА [20]. The shear failure load on one plane of the bolt is 1285 kg, and the tensile failure load is 1480 kg. The cross-section of the beam (fig. 3.9), on which the teeth are held, will have a closed contour with walls of 5 mm and 8 mm. A simplified diagram of the rail loading and distances between gears and vertical supports are shown in figure 3.10.

$$R_2^P \cdot (K+M+N) - P_{y1}^P \cdot K - P_{y2}^P \cdot (K+M) = 0.$$

$$R_2^P = \frac{P_{y1}^P \cdot K + P_{y2}^P \cdot (K+M)}{K+M+N} = \frac{187.5 \cdot 30 + 187.5 \cdot (30+60)}{30+60+30} = 187.5\,(kgf) = 1838.7\,(N).$$

$$R_1^P \cdot (K+M+N) - P_{y2}^P \cdot N - P_{y1}^P \cdot (M+N) = 0.$$

$$R_1^P = \frac{P_{y1}^P \cdot (M+N) + P_{y2}^P \cdot N}{K+M+N} = \frac{187.5 \cdot (60+30) + 187.5 \cdot 30}{30+60+30} = 187.5\,(kgf) = 1838.7\,(N).$$

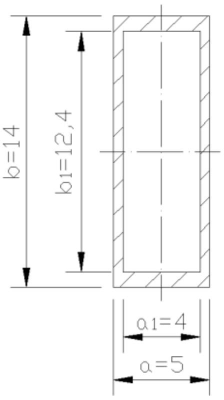


Fig. 3.9. Cross-section of the beem.

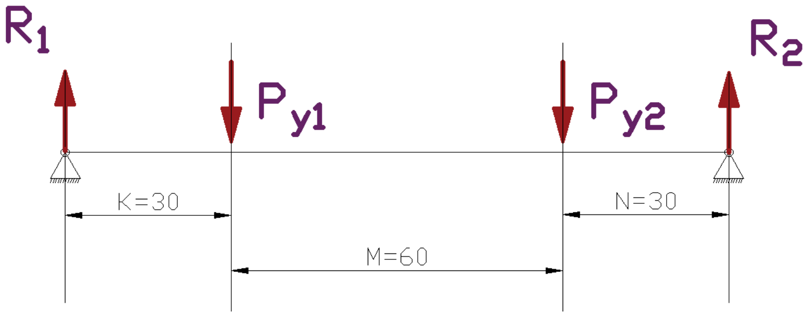


Fig. 3.10. Loading scheme of the beem.

Moment of inertia of the beam:

$$J_x = \frac{1}{12} \cdot \left(ab^3 - a_1 b_1^3\right) = \frac{1}{12} \cdot \left(5 \cdot 14^3 - 4 \cdot 12.4^3\right) = 507.792\,\left(cm^4\right).$$

The deflection at the midpoint of the span is:

$$f = \frac{P^{P} \cdot N}{24 \cdot E \cdot J_{x}} \cdot \left(3 \cdot l^{2} - 4 \cdot c^{2}\right) = \frac{187.5 \cdot 30}{24 \cdot 2100000 \cdot 507.792} \cdot \left(3 \cdot 120^{2} - 4 \cdot 30^{2}\right) = 0.0087\,(cm),$$

where E – is the Young's modulus for steel 30ХГСА. So, was calculated that the thin-walled beam on which the teeth are held can withstand the specified loads. The deflection will be minimal, so the movement of the patient along the aircraft cabin will be smooth and calm.

During emergency landing, the following overloads will be experienced by the escalator:

$n_x = 9$; $n_x = -3$;

$n_y = 3$; $n_y = -6$;

$n_z = \pm 1.5$.

Equipment weight in flight – 120 kg. Firstly, the case of overloading at 1.5 during the aircraft roll was considered. The center of gravity of the entire structure is placed at the geometric center and equidistant from all (p.41, p.42, p.31, p.32) attachment points (fig. 3.11).

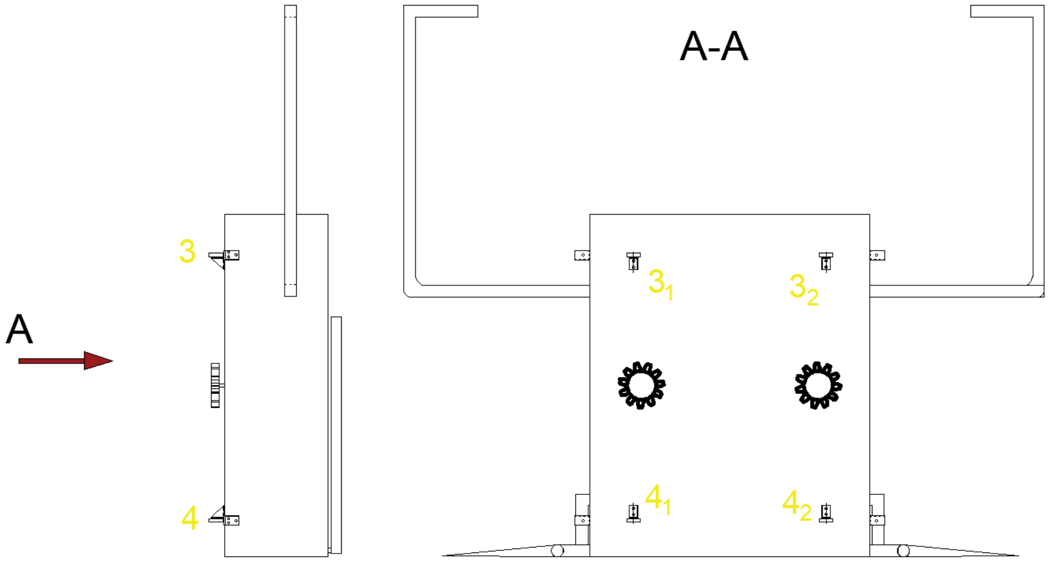


Fig. 3.11. Attachment points.

Taking into account the unevenness coefficient ($k_{unev} = 1.3$), the load on one roller will be:

$$P_z^P = G \cdot n_z^P \cdot k_{irr} \cdot \frac{1}{4} = 120 \cdot 1.5 \cdot 1.3 \cdot \frac{1}{4} = 58.5\,(kgf) = 573.7\,(N),$$

where, G – the mass of the escalator without the stretcher and patient in the folded position. Recalculating the load on the roller (fig. 3.12), we obtain the following values:

$$P_{z31}^P = 58.5\,(kgf) = 573.7\,(N).$$

$$M^P = P_{z31}^P \cdot L = 58.5 \cdot 0.82 = 47.97\,(kgf \cdot cm) = 4704\,(\mathrm{N \cdot mm}).$$

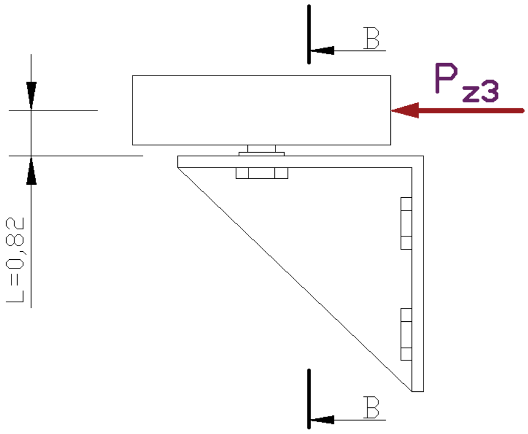


Fig. 3.12. Cross-section B-B.

Let's consider cross-section B-B (fig. 3.13). The cross-sectional area is:

$$F = 0.96\,(cm^2) = 96\,(mm^2).$$

Section modulus about the neutral axis [21]:

$$W_{up} = 0.682\,(cm^3) = 682\,(mm^3).$$

$$W_{down} = 0.212\,(cm^3) = 212\,(mm^3).$$

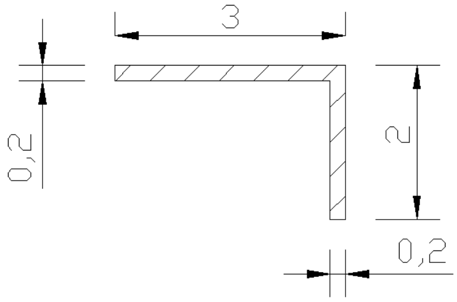


Fig. 3.13. Cross-section B-B.

Stresses in cross-section:

$$\sigma^P = \frac{M^P}{W_{down}} = \frac{47.97}{0.212} = 226.2\left(kgf/cm^2\right) = 22.2\left(N/mm^2\right).$$

Safety factor:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{4100}{226.2} = 18.12\,.$$

Let's consider the longitudinal rail. Calculated case $n_x = 9$.

Calculated loads:

$$P_x^P = G \cdot n_x^P = 120 \cdot 9 = 1080\left(kgf\right) = 10591\left(N\right).$$

The load P_x^P is applied at two points a and b:

$$P_{xa}^P = P_{xb}^P = \frac{P_x^P}{2} = \frac{1080}{2} = 540\left(kgf\right) = 5295.6\left(N\right).$$

A case was considered where the load of $n_x = 9$ acts on one pair of side studs (fig. 3.14).

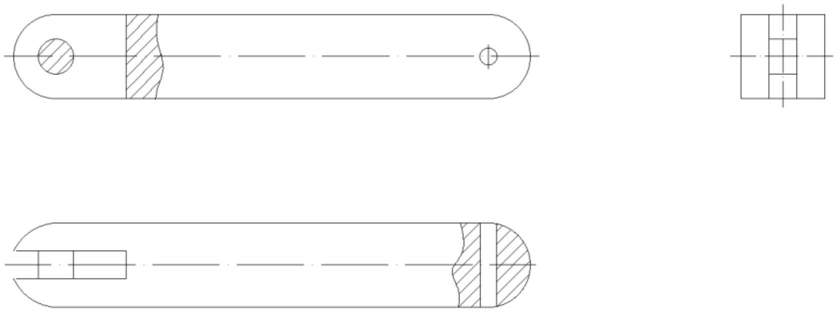


Fig. 3.14. Illustration of the stud.

To prevent the escalator from moving along the aircraft cabin during the flight, it was decided to secure it using four studs. Each stud has a special axis onto which a tongue is attached, preventing the stud from falling out. Let's assume that the stud is fixed on the left side. Therefore, the simplified scheme of attaching one of the studs to the lateral restrictors will look as on figure 3.15:

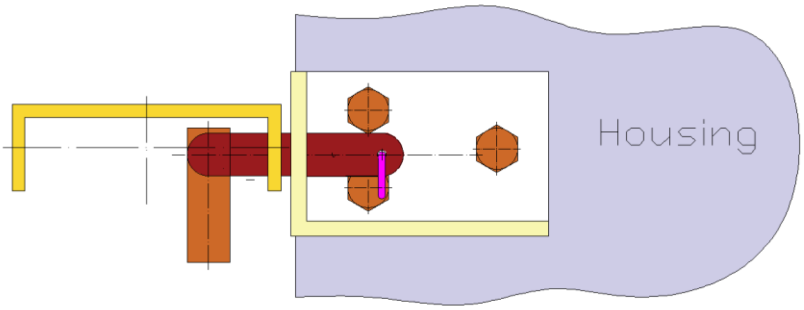


Fig. 3.15. Fixation scheme of the escalator during flight.

To choose the required diameter of the stud, we express the section modulus of the cross-section from the formula of normal load. The stud is made of steel.

$$\sigma^P = \frac{P_{xa}^P \cdot l}{W} = \sigma_{ult},$$

$$W = \frac{P_{xa}^P \cdot l}{\sigma_{ult}} = \frac{540 \cdot 0.75}{11000} = 0.037\left(cm^3\right) = 37\left(mm^3\right).$$

So it was decided to choose a stud with a diameter of 8 mm.

$$F = \pi \cdot r^2 = 3.14 \cdot 0.4^2 = 0.5027\left(cm^2\right) = 50.27\left(mm^2\right).$$

$$W = \frac{\pi \cdot D^3}{32} = \frac{\pi \cdot 0.4^3}{32} = 0.0503\left(cm^3\right) = 50.3\left(mm^3\right).$$

The distance between the outer walls of the bracket and the rail will be 2 mm to avoid friction. Taking into account the thickness of the rail and bracket walls, the load scheme will look like the one shown in figure 3.16.

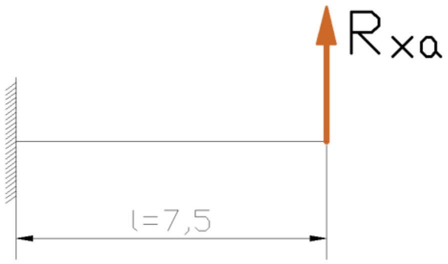


Fig. 3.16. The load scheme of the pin on the walls of the rail and bracket.

The top view indicates the points where the main load is applied. The pin presses on points a and b, as shown in figure 3.17.

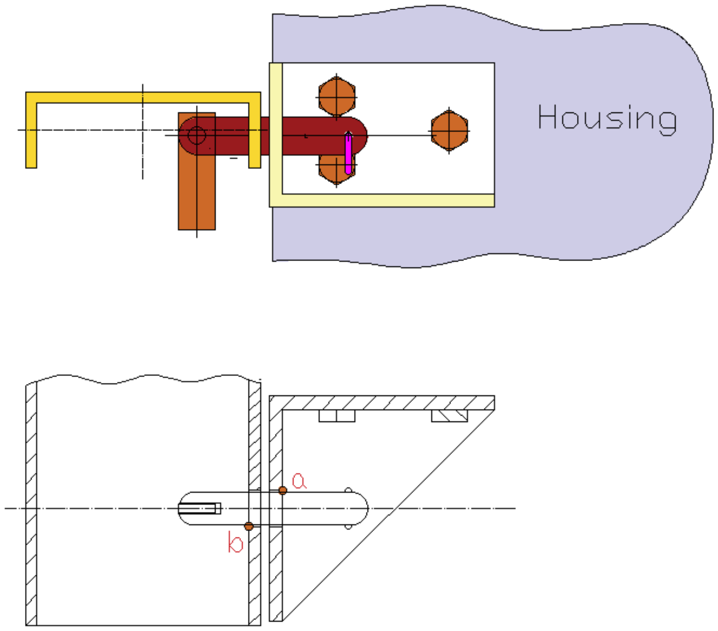


Fig. 3.17. Loaded points.

Stresses in the stud:

$$\sigma^P = \frac{P_{xa}^P \cdot l}{W} = \frac{540 \cdot 0.75}{0.0503} = 8052\left(kgf/cm^2\right) = 789.6\left(N/mm^2\right).$$

$$\tau^P = \frac{P_{xa}^P}{F} = \frac{540}{0.5027} = 1074\left(kgf/cm^2\right) = 105.3\left(N/mm^2\right).$$

$$\sigma_{eq}^P = \sqrt{\sigma^2 + 4 \cdot \tau^2} = \sqrt{8052^2 + 4 \cdot 1074^2} = 8334\left(kgf/cm^2\right) = 817.3\left(N/mm^2\right).$$

Safety factor:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{11000}{8334} = 1.3.$$

The bracket, which has a hole for the pin to fix the escalator in its stationary position, is attached to the control box using three bolts. Two bolts at point 1 work under tension, while a bolt at point 2 works under compression. (fig. 3.18).

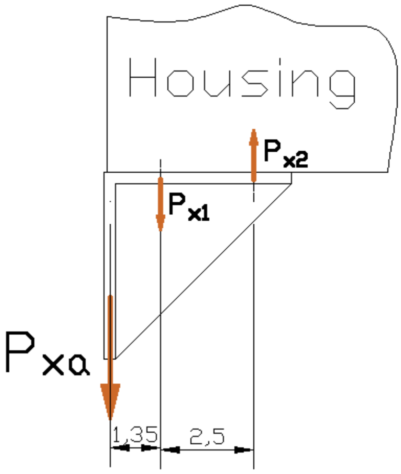


Fig. 3.18. P_{xa} load along Ox axes.

P_{x1} та P_{x2} calculation:

$$P_{x1}^{P} = \frac{P_{xa}^{P} \cdot (c+d)}{d} = \frac{540 \cdot (1.35+2.5)}{2.5} = 832\,(kgf) = 8159\,(N).$$

$$P_{x2}^{P} = -\frac{P_{xa}^{P} \cdot c}{d} = \frac{540 \cdot 1.35}{2.5} = -292\,(kgf) = -2863.5\,(N).$$

Loading on 3 bolts (fig. 3.19):

a) Under tension:

$$P_{x3}^{P} = P_{x4}^{P} = \frac{P_{x1}^{P}}{2} = \frac{832}{2} = 416\,(kgf) = 4079.6\,(N).$$

b) Under compression:

$$P_{x5}^{P} = P_{x2}^{P} = -292\,(kgf) = -2863.6\,(N).$$

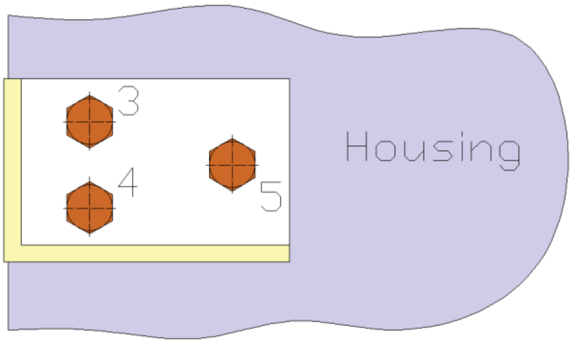


Fig. 3.19. Bolt connections.

Stress in a steel bolt with a diameter of 5 mm:

$$\sigma^{P} = \frac{P_{x3}^{P}}{F} = \frac{416}{0.1964} = 2118\left(kgf\,/\,cm^{2}\right) = 207.85\left(N\,/\,mm^{2}\right).$$

Stress factor:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{11000}{2118} = 5.2\,.$$

Let's consider the cross-section A-A of the bracket, which will hold the escalator in unmovable position along the Ox axis (fig. 3.20). The cross-sectional area will be:

$$F = 2.055\left(cm^{2}\right) = 205.5\left(mm^{2}\right).$$

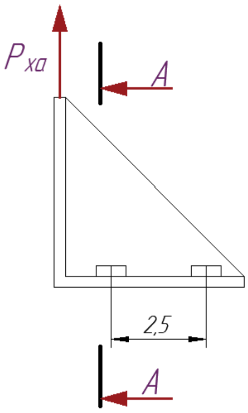


Fig. 3.20. Loading og the bracket.

Section modulus about the neutral axis (fig. 3.21):

$$W_{up} = 0.711\left(cm^3\right) = 711\left(mm^3\right);$$

$$W_{down} = 2.167\left(cm^3\right) = 2167\left(mm^3\right);$$

$$W_{right} = 2.742\left(cm^3\right) = 2742\left(mm^3\right);$$

$$W_{left} = 1.273\left(cm^3\right) = 1273\left(mm^3\right).$$

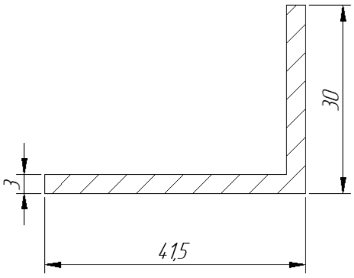


Fig. 3.21. Cross-section A-A.

Moment:

$$M^P = P_{xa}^P \cdot l = 540 \cdot 1 = 540\left(kgf \cdot cm\right) = 52956\left(\mathrm{N} \cdot \mathrm{mm}\right).$$

Normal stress:

$$\sigma^P = \frac{M^P}{W} = \frac{540}{1.273} = 424\left(kgf\,/\,cm^2\right) = 41.6\left(N\,/\,mm^2\right).$$

Safety factor:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{4100}{424} = 9.7\,.$$

During the overload at $n_y = -6$ (fig. 3.22), acting downward, the gears take the majority of th load, thus:

$$P_y^P = G \cdot n_y = 120 \cdot \left(-6\right) = -720\left(kgf\right) = -7060.8\left(N\right).$$

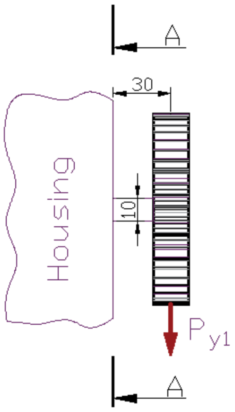


Fig. 3.22. Overloading n_y = -6.

The load on one gear:

$$P_{y1}^{P} = \frac{P_y^P}{2} = \frac{-720}{2} = -360\,(kgf) = -3530.4\,(N).$$

Stresses in the cross section A-A:

$$\tau^P = \frac{P_{y1}^P}{F} = \frac{360}{0.7854} = 458\left(kgf/cm^2\right) = 44.9\left(N/mm^2\right).$$

$$\sigma^P = \frac{P_{y1}^P \cdot l}{W} = \frac{360\cdot 3}{0.0982} = 10998\left(kgf/cm^2\right) = 1077.5\left(N/mm^2\right).$$

$$\sigma_{eq}^P = \sqrt{\sigma^2 + 4\cdot\tau^2} = \sqrt{10998^2 + 4\cdot 458^2} = 11036\left(kgf/cm^2\right) = 1082\left(N/mm^2\right).$$

Safety factor:

$$\eta = \frac{\sigma_{ult.str}}{\sigma_{equivalent.str}} = \frac{11000}{11036} = 0.99\,.$$

Therefore, it has been proven that the escalator structure will withstand the n_y = -6 overload acting downward.

If the overload were to act upward n_y = 3 then the calculated load would be:

$$P_y^P = G\cdot n_y = 120\cdot 3 = 360\,(kgf) = 3530.4\,(N).$$

The load is supported by two pins at points a and b (fig. 3.23).

$$P_{ya}^P = P_{yb}^P = \frac{P_y^P}{2} = \frac{360}{2} = 180\,(kgf) = 1765.2\,(N).$$

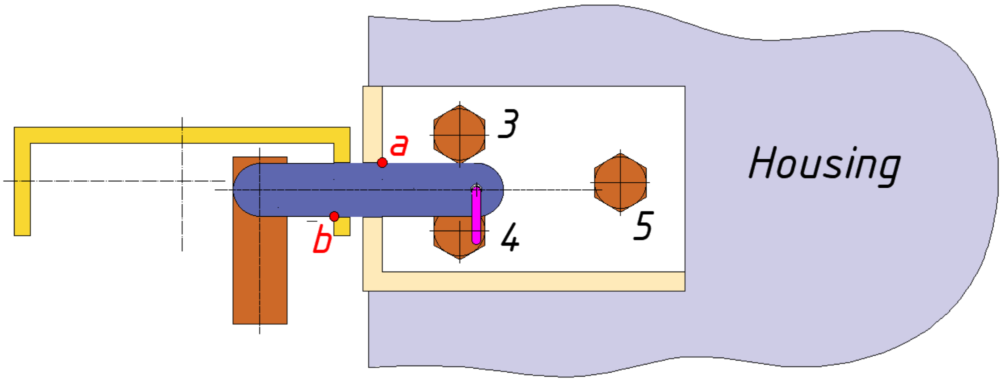


Fig. 3.23. Loading on bolts and stud.

The load at points 3, 4, and 5:

$$P_{y3}^{P} = P_{y4}^{P} = \frac{1}{2}\cdot\frac{P_{ya}^{P}\cdot(b+a)}{b} = \frac{1}{2}\cdot\frac{180\cdot(2.5+1.35)}{2.5} = 138.6\,(kgf) = 1359.2\,(N).$$

$$P_{y5}^{P} = -\frac{P_{ya}^{P}\cdot a}{b} = -\frac{180\cdot 1.35}{2.5} = -97.2\,(kgf) = -953.2\,(N).$$

Shear of the bolt 3:

$$F = \pi\cdot r^{2} = 3.14\cdot 0.25^{2} = 0.1964\,(cm^{2}) = 19.64\,(mm^{2}).$$

$$\tau^{P} = \frac{P_{y3}^{P}}{F} = \frac{138.6}{0.1964} = 705.7\,(kgf/cm^{2}) = 69.2\,(N/mm^{2}).$$

$$\sigma_{shear} = 0.6\cdot\sigma_{ult} = 0.6*11000 = 6600\,(kgf/cm^{2}) = 647.24\,(N/mm^{2})$$

Safety factor:

$$\eta = \frac{0.6\cdot\sigma_{ult.str}}{\tau^{P}} = \frac{6600}{705.7} = 9.4$$

Conclusions to the special part

As a conclusion, in order to provide the information on the concept level of sanitary equipment, the components of the sanitary equipment which involves rollers, brackets, stud, gears, rails, and beam have been discussed here. It is to be noted that the structural members of the escalator have been analyzed in terms of strength and thus, their reliability has been successfully ascertained. Subsequently, the internal components of the control box were analyzed with the possibility of its replacement according to the speed of the escalator and battery features.

This project of installing the escalator for operating stretchers has come out successfully in lessening the time for loading and lessening the manual loading that was required earlier. In 85 minutes, the airplane from the key factors of the survey, including staff, equipment, patients, and needed medical equipment, will be prepared for the flight. This ensures that all the requirements in regard to their transportation as well as their medical status during the flight have been met adequately.

GENERAL CONCLUSIONS

Original equipment for the sanitary aircraft has been developed.

In the process of the work the following tasks have been solved:

1. To make preliminary design of the short-range cargo aircraft. Preliminary design includes: calculation of geometrical characteristics of the wing, fuselage, tail unit and determination of the loadings acted on landing gear;
2. The centering of the plane is in the typical range for the planes of the short and mid range category. In the process of the aircraft centering calculations to account for the accommodation of special sanitary equipment;
3. Key elements of the sanitary equipment have been defined at the concept level. They are: rollers, brackets, studs, gears, rails, beam;
4. The application of an escalator for stretchers has successfully reduced loading times and minimized the need for human effort;
5. Calculations of escalator’s structural elements strength was carried out;
6. Further steps for the sanitary equipment design are proposed;

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Appendix A

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Performed by: Lozovsky Ivan
Supervisor: Mykhailo Karuskevych

                       PRELIMINARY DESIGN OF THE AIRCRAFT
                      INITIAL DATA AND SELECTED PARAMETERS

Passenger Number                                                      17
Flight Crew Number                                                     2
Flight Attendant or Load Master Number                                 3
Mass of Operational Items                                           1050.0 kg
Payload Mass                                                       20000.0 kg

Cruising Speed                                                       825.0 km/h
Cruising Mach Number                                                   0.7732
Design Altitude                                                       11.0 km
Flight Range with Maximum Payload                                   1000.0 km
Runway Length for the Base Aerodrome                                   2.55km

Engine Number                                                          2.0
Thrust-to-weight Ratio in N/kg                                         2.52
Pressure Ratio                                                        22.0
Assumed Bypass Ratio                                                   5.0
Optimal Bypass Ratio                                                   5.0
Fuel-to-weight Ratio                                                   0.2800

Aspect Ratio                                                          10.7
Taper Ratio                                                            3.75
Mean Thickness Ratio                                                   0.118
Wing Sweepback at Quarter Chord                                       27.0  deg
High-lift Device Coefficient                                           0.970
Relative Area of Wing Extensions                                       0.010
                       Wing Airfoil Type - supercritical
                       Winglets – are used
                       Spoilers - established

Fuselage Diameter                                                      3.95 m
Finess Ratio                                                           8.16
Horizontal Tail Sweep Angle                                           30.0  deg
Vertical Tail Sweep Angle                                             35.0  deg


CALCULATION RESULTS

Optimal Lift Coefficient in the Design Cruising Flight Point           0.44300

Induce Drag Coefficient                                                0.00912

ESTIMATION OF THE COEFFICIENT    Dm = Mcritical – Mcruise
Cruising Mach Number                                                   0.77317
Wave Drag Mach Number                                                  0.78367
Calculated Parameter Dm                                                0.01049

Wing Loading in kPa (for Gross Wing Area):
                           At Takeoff                                  4.497
                           At Middle of Cruising Flight                4.218
                           At the Beginning of Cruising Flight         4.332
Drag Coefficient of the Fuselage and Nacelles                          0.00955
Drag Coefficient of the Wing and Tail Unit                             0.00913

Drag Coefficient of the Airplane:
                           At the Beginning of Cruising Flight         0.02906
                           At Middle of Cruising Flight                0.02881
```

```
Mean Lift Coefficient for the Ceiling Flight                           0.44300

Mean Lift-to-drag Ratio                                               15.37475

Landing Lift Coefficient                                               1.594
Landing Lift Coefficient (at Stall Speed)                              2.391
Takeoff Lift Coefficient (at Stall Speed)                              1.992
Lift-off Lift Coefficient                                              1.454
Thrust-to-weight Ratio at the Beginning of Cruising Flight             0.639
Start Thrust-to-weight Ratio for Cruising Flight                       2.671
Start Thrust-to-weight Ratio for Safe Takeoff                          2.650

Design Thrust-to-weight Ratio                                          2.778

Ratio Dr = Rcruise / Rtakeoff                                          1.008


                    SPECIFIC FUEL CONSUMPTIONS (in kg/kN*h):
                 Takeoff                                              38.7399
                 Cruising Flight                                      60.2537
                 Mean cruising for Given Range                        60.6726

                             FUEL WEIGHT FRACTIONS:
                                        Fuel Reserve     0.03552
                                        Block Fuel       0.08484

                      WEIGHT FRACTIONS FOR PRINCIPAL ITEMS:
                        Wing                               0.13887
                        Horizontal Tail                    0.01662
                        Vertical Tail                      0.01887
                        Landing Gear                       0.04554
                        Power Plant                        0.09137
                        Fuselage                           0.12951
                        Equipment and Flight Control       0.12340
                        Additional Equipment               0.00342
                        Operational Items                  0.01557
                        Fuel                               0.12036
                        Payload                            0.29989

                Airplane Takeoff Weight - 67453 kg
        Takeoff Thrust Required of the Engine - 93.70 kN

Air Conditioning and Anti-icing Equipment Weight Fraction             0.0160
Passenger Equipment Weight Fraction                                   0.0006
(or Cargo Cabin Equipment)
Interior Panels and Thermal/Acoustic Blanketing Weight Fraction       0.0069
Furnishing Equipment Weight Fraction                                  0.0262
Flight Control Weight Fraction                                        0.0065
Hydraulic System Weight Fraction                                      0.0175
Electrical Equipment Weight Fraction                                  0.0201
Radar Weight Fraction                                                 0.0058
Navigation Equipment Weight Fraction                                  0.0087
Radio Communication Equipment Weight Fraction                         0.0043
Instrument Equipment Weight Fraction                                  0.0101
Fuel System Weight Fraction                                           0.0035

           Additional Equipment: = СУММА =>
Equipment for Container Loading                                       0.0000
No typical Equipment Weight Fraction                                  0.0034

(Build-in Test Equipment for Fault Diagnosis.
Additional Equipment of Passenger Cabin)

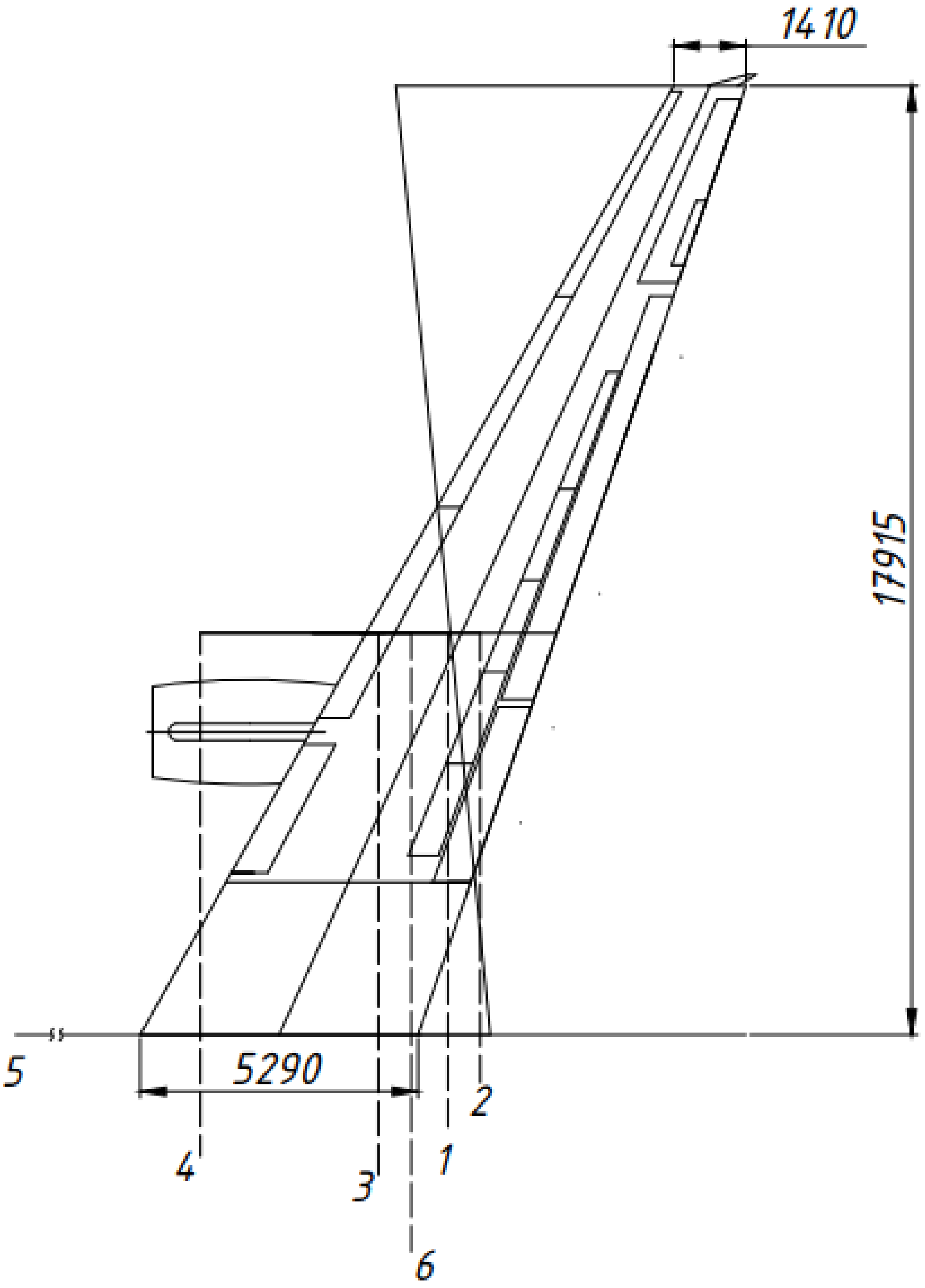
TAKEOFF DISTANCE PARAMETERS
```

```
Airplane Lift-off Speed                                             253.10 km/h
Acceleration during Takeoff Run                                       2.13 m/s2
Airplane Takeoff Run Distance                                       1155.   m
Airborne Takeoff Distance                                            578.   m
Takeoff Distance                                                    1733.   m

CONTINUED TAKEOFF DISTANCE PARAMETERS
Decision Speed                                                       240.45 km/h
Mean Acceleration for Continued Takeoff on Wet Runway                  0.25 m/s2
Takeoff Run Distance for Continued Takeoff on Wet Runway            2008.09 m
Continued Takeoff Distance                                          2586.47 m
Runway Length Required for Rejected Takeoff                         2681.19 m

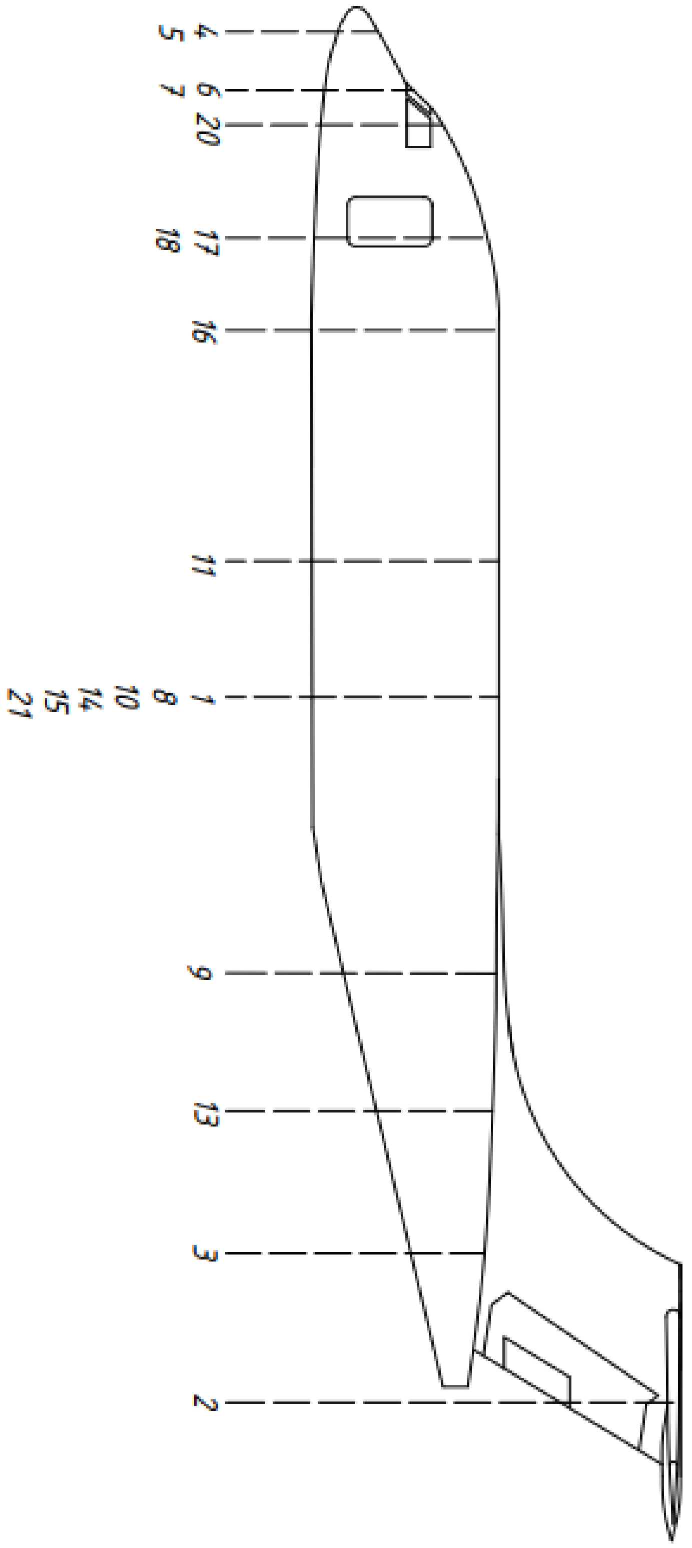
LANDING DISTANCE PARAMETERS
Airplane Maximum Landing Weight                                    64711.   kg
Time for Descent from Flight Level
(till Aerodrome Traffic Circuit Flight)                               21.5  min
Descent Distance                                                      49.23 km
Approach Speed                                                       254.63 km/h
Mean Vertical Speed                                                    2.04 m/s
Airborne Landing Distance                                            519.   m
Landing Speed                                                        239.63 km/h
Landing run distance                                                 783.   m
Landing Distance                                                    1302.   m
Runway Length Required for Regular Aerodrome                        2174.   m
Runway Length Required for Alternate Aerodrome                      1849.   m
```

Appendix B



1. Wing, fuel system, fuel
2. Flight control system, hydraulic system
3. Electrical equipment, anti-ice system
4. Engines(without fuel system)
5. Nose landing gear
6. Main landing gear

Appendix C



1. Fuselage
2. Horizontal tail
3. Vertical tail
4. Radar
5. Radio equipment
6. Instrument panel
7. Navigation equipment
8. Flight control system
9. Hydraulic system
10. Electrical equipment
11. Not typical equipment
12. Lining and insulation
13. Anti-ice system
14. Airconditioning system
15. Medical equipment
16. Furnishing
17. Operational items
18. Editional equipment
19. Galley
20. Crew seats