

The basic principles of increasing the density of multi-story residential development

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Abstract: *The article discusses the principles of increasing the density of residential buildings by including various types of residential buildings with high floors (16-18 floors) while ensuring a standardized duration of insolation of apartments. The necessary distances between the facades of the houses to ensure sanitary standards in the apartments and the functional requirements for the organization of courtyard spaces are determined.*

Keywords: *Single-section houses, multi-section houses, standardized insolation, residential development, courtyard space, tower houses, planning structure, shading schedules, latitudinal location of houses, distances between the facades of houses.*

1. INTRODUCTION

The rapid population growth in Uzbekistan, especially in the capital - Tashkent and large cities, as well as the limitation of the possibility of expanding the territory of cities, forces the construction of houses with higher floors and an increase in the density of housing stock. According to the urban development standards of Uzbekistan (ShNK 2.07.01 - 0.3 *), the distance between the facades of 9 storey buildings should be at least 40 m. between the long facades and ends of buildings with windows - 22-25m [1]. The specified regulatory document does not say anything about the distances between houses of 16, 18 and more floors.

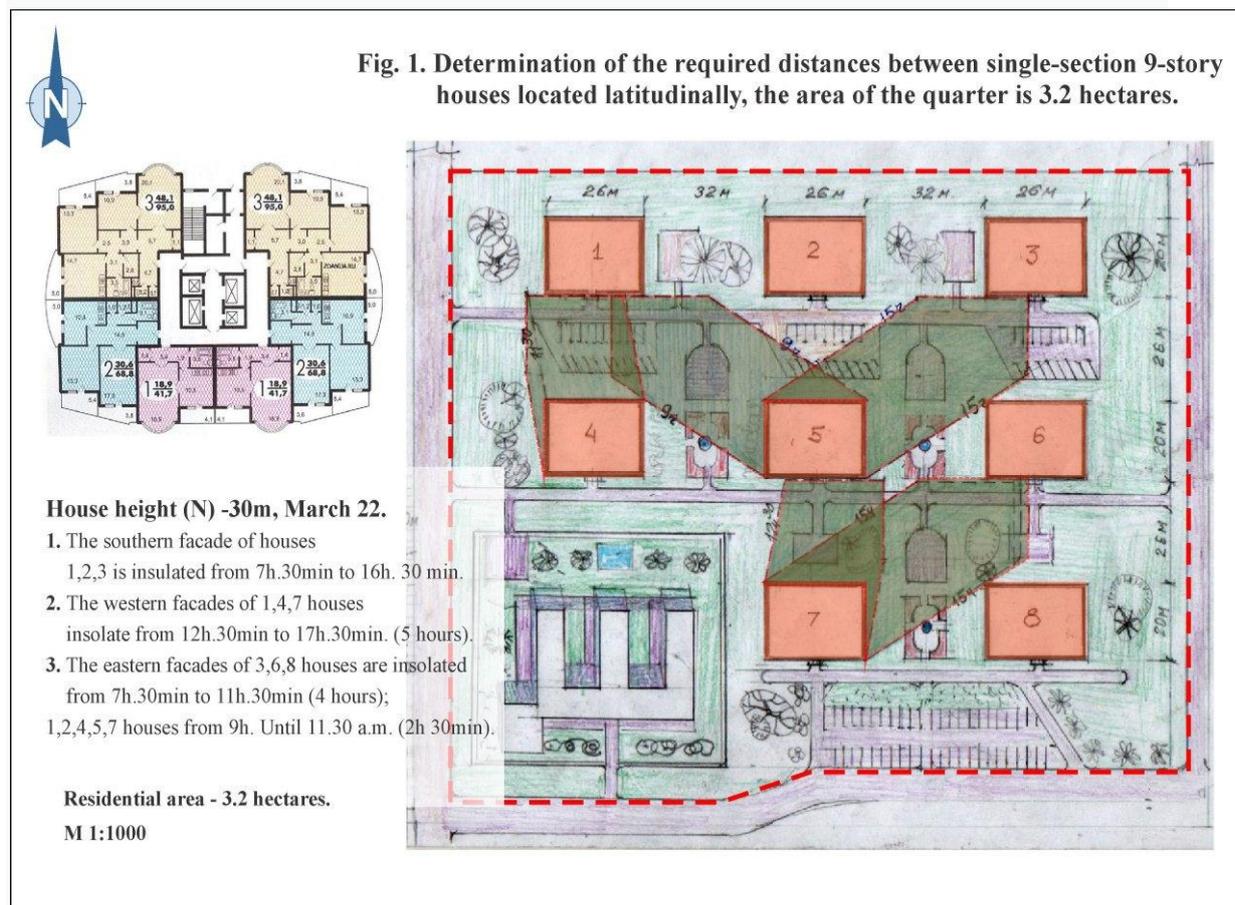
distances between the facades of 9 and 18 storey buildings, providing 2.5 hour insolation of each apartment.

category of the building from 6 to 15 meters [2]. It is clear that such distances between multi-storey buildings will not only provide the necessary insolation of apartments, but also do not provide the opportunity to organize a normal light climate of residential premises and to place a sufficient number of playgrounds, car parks and green spaces in the courtyard. Currently, designers are increasing the number of storeys of buildings. However, they did not investigate how this could be due to the number of storeys of houses and the gaps between their facades.

2. MAIN PART

Consider a nine-story residential area of 3.2 hectares, consisting of 8 one-section houses. One-sectional house in the plan is solved with dimensions of 20x26 meters. On each floor there are three three-room and one four-room apartments (Fig. 1). Insolation of the three facades is necessary here. Therefore, we will place these houses on the site with a long facade (26 m) parallel to the latitude, then only one northern facade of all houses will not be insulated.

However, due to the insulation of the western, eastern and southern (main) facades, all



apartments of the house, with the necessary gaps, will be provided with the necessary duration of insolation in accordance with regulatory requirements.

The insolation of the premises of the apartments (facades) is determined by the height and azimuth of the sun on March 22 (September). The regulatory document (ShNK 2.07.01 - 0 3 *) states the need for 2.5 hours of insolation from March 22 to September 22. However, in the summer (June, July, August) the duration of the sunshine and the height of the sun is longer and higher than March 22. Therefore, the gaps between the houses, determined by the coordinates of the sun in March (September) month, will fully meet the regulatory requirements and will provide a longer insolation of the facades of the house than in March. In general, in Uzbekistan, because of the dry, hot summer, sun protection of windows during this period is necessary, and not insolation

[3]. In winter, due to the low position of the sun (the height of the sun at noon reaches only 25° - 30°).

The proportion of ultraviolet radiation is very small and the necrobiotic (antimicrobial) effect of sunlight is low. On March 22, the angle of the sun's rays in the plane perpendicular to the vertical plane of the southern orientation (profile angle β) will be the same from morning to evening, $\beta = 90^{\circ} - \varphi$ (where φ is the latitude of the construction site, degrees). With $\varphi = 40^{\circ}$ (the average latitude of Uzbekistan), $\beta = 90^{\circ} - 40^{\circ} = 50^{\circ}$.

In the book of I.S. Sukhanov's "Radiant Energy of the Sun and Architecture" shows shading lines from buildings of various heights on March 22 for a latitude of 41° [4]. This graph also shows that the profile angle of the sun is the same from morning to evening.

Using this graph and descriptive geometry methods, envelopes of shadows on a horizontal surface from nine-story buildings with a height (H) of 30 m were determined. The shadow envelopes show that the 4th, 5th, 6th houses do not obscure the first, second, third houses, and the 7th and 8th houses are the fifth and sixth houses located to the north at a distance of 26 meters along the meridian. That is, the shadow length along the meridian is $L_{\text{shadow}} = H \times \text{ctg } 50^{\circ} = 30\text{m} \times 0.84 = 26\text{m}$. In other words, 4, 5, 6 houses from morning until evening (from 9 to 15 hours) will not obscure the southern facades of the first, second, third houses, and 7 and 8 houses the southern facades of the fourth, fifth and sixth houses located at a distance of 26 meters the meridian.

The eastern facades of the first, second, fourth, fifth and seventh houses insolate from 9 to 11 hours 30 minutes, i.e. 2.5 hours with a gap between the facades in latitude 32m. The southern, western and eastern facades of all eight houses insolate for 2.5 hours or more at distances between facades of 20-35% below the regulatory requirements. This allows you to increase the density of residential buildings.

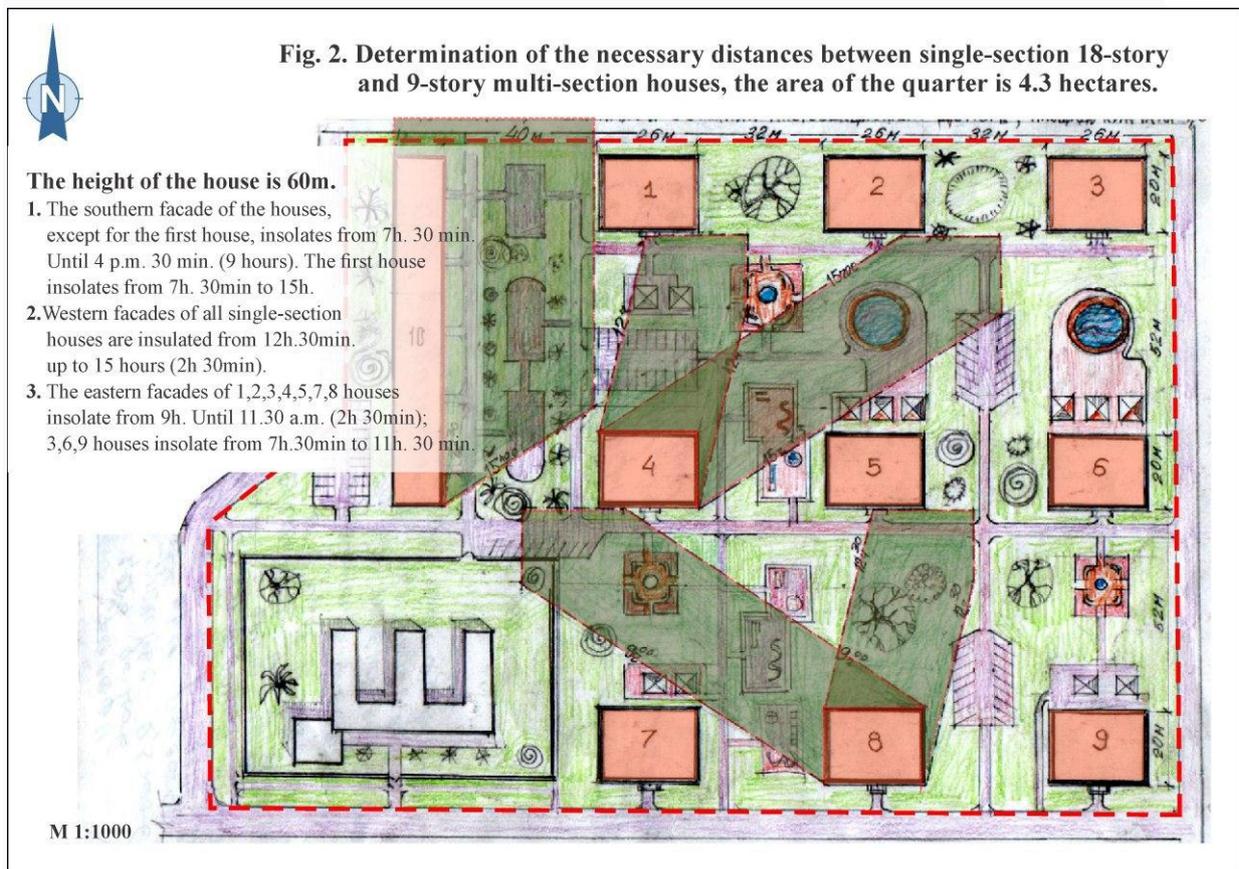
Consider a residential area of 4,3 hectares, where nine 18-story tower houses and one five-section long house with 4-5 room apartments are located. With meridional gaps between the facades of houses equal to 52 meters and latitudinal gaps of 32 meters, the required insolation of all apartment buildings is provided (Fig. 2). Judging by the envelope of shadows, the nine-story meridional house should be removed from the facade of the first and fourth 18-story houses at a distance of 40 meters. The distances between the facades of 9 and 18 storey five-section houses were also analyzed, providing the necessary duration of insolation when they are set meridionally, i.e. long axis parallel to the north-south direction. We have chosen a quarter of 3.8 hectares, consisting of five nine-story houses. Of these, four houses were delivered meridionally, and one - wide (Fig. 3). In the quarter, a territory was allocated (0.7 hectares) for a kindergarten.

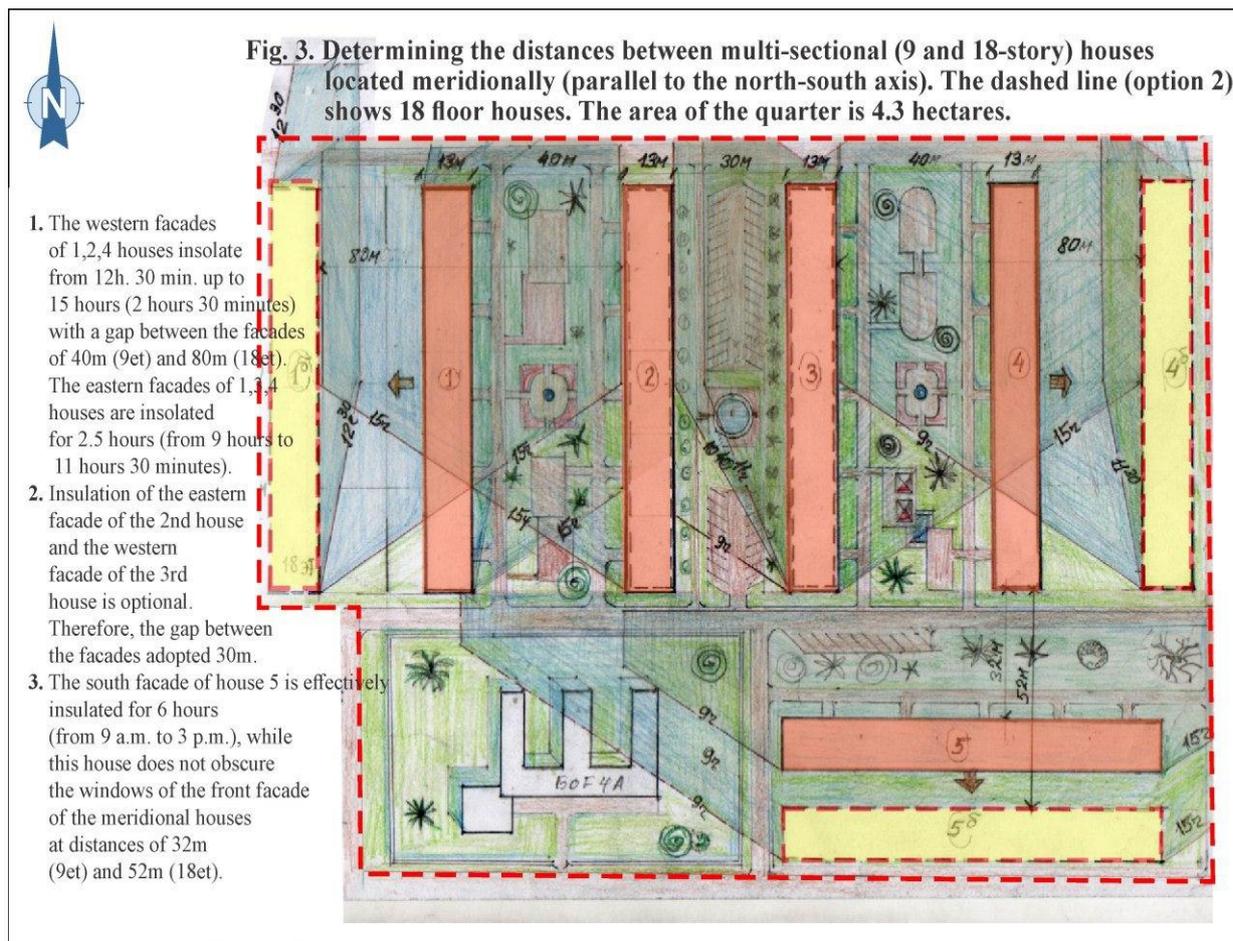
Judging by the envelopes of shadows built on the heights and azimuths of the sun on March 22, the western facades of houses 1, 2 and 4 insolate for 2.5 hours (from 12.30 to 15 hours) with a distance between the facades of 40 meters. This complies with regulatory requirements. The planning feature of these multi-sectional houses is that here the apartments face two opposite facades (W - B) and the insolation of one room in a three-room apartment and two rooms in a four-room apartment overlooking one facade makes it possible to satisfy regulatory requirements (ShNK 2.08.01 - 05, "Residential buildings"). In this regard,

insolation of the eastern facade of the second house and the western facade of the third house is not required. Therefore, the width of the yard between these houses can be taken according to the functional necessity of arranging driveways, green spaces and taken equal to 30 meters. The necessary playgrounds for children's games, adult relaxation, and parking can be arranged in the space between houses 1 and 2, 3 and 4.

The southern façade of the fifth house, set in latitude, is effectively insulated for 6 hours (from 900 to 15 hours). To prevent shading of the windows of living rooms overlooking the front facade of the third and fourth meridional houses, as well as placing the necessary zones in the yard, the fifth house should be placed at a distance of 32 meters from these houses.

The density of the housing stock in the quarter with the gaps between the houses, determined from the conditions of the necessary insolation, turned out to be 8210 m² / ha, i.e. 30% higher than regulatory requirements.





Let's see what density of housing stock will be in this quarter, if we have the same houses, but not 9 storey, but 18 storey. The total area of all apartments in the quarter will be 60,480 m².

To ensure a sufficient duration of insolation of houses, it will already be necessary to increase the distance between the eastern and western facades to 80 meters, and between the end of the meridional houses to the facade of the latitudinal house to 52 meters. To accommodate five 18-story houses an increase in the area of the quarter by 15% is required, then it will be 4.3 hectares. The density of the housing stock will be 11500 m² / ha. This is a fairly high rate.

3. LITERARY REVIEW (III. LITERATURE SURVEY)

The main role in determining the gaps between the facades of houses is played by the provision of standardized insolation of apartments according to sanitary and hygienic requirements. The doctor of architecture I.S. noted the need for a three-hour insolation. Sukhanov [4]. Why exactly the three-hour insolation? In the "Petri dish", placed on the windowsill for double glazing, E. coli die in 2-3 hours. Therefore, it is so important that each living room in the apartment receives continuous insolation for 2 to 3 hours. Therefore, it is so important that each living room in the apartment receives continuous insolation for 2 to 3 hours. According to the norms of designing residential buildings in Uzbekistan, insolation is required for 2.5 hours in one room in 1-2-3 room apartments and

two rooms in 4-5-6 room apartments [5]. Based on these considerations, the necessary gaps between the facades of residential buildings are established. This suggests that the entire surface of the facade of the house should be insulated for 2.5 hours. It should be noted that an excessive increase in the gaps between the houses, to improve the ventilation of the yard space in the summer, leads to a decrease in the density of residential buildings [6]. The planning structure of the courtyard spaces (closed or open) depending on climatic conditions and the wind regime was considered by architect G.K. Goldstein [7].

According to the architect G.O. Korbut, the most preferred orientation of the apartment's living rooms is south. In spring, autumn, especially in winter, a living room of this orientation receives prolonged sun exposure. In summer, when the sun is high, a small visor is enough to protect the light of this room [3]. According to the architect G.K. Goldstein and regulatory documents of Uzbekistan are not recommended orientation of living rooms to the southwest and west side of the horizon (sector in the range of $200^{\circ} - 290^{\circ}$) without the installation of adjustable sunscreens, since the large heat input from the sun with this orientation coincides with the daily maximums of the outside temperature [7].

4. METHODOLOGY

The necessary distance between the facades of the houses of I.S. Sukhanov recommends that, according to the schedules he constructed, the shadows for March 22 [G.K]. However, only these graphs are not enough. To solve this problem, one should construct envelopes of shadows from shading buildings on a horizontal surface using descriptive geometry methods and hourly data on the height and azimuth of the sun on March 22 for 40° Northern latitude. Most importantly, there shouldn't be any shadow on the building's facade under consideration. Latitude 40° is the average latitude of Uzbekistan and the results of calculations, constructions of shadow envelopes will satisfy all areas of our country.

The device "Insolameter - I 60" proposed by N.V. Obolensky calculates the number of hours and the area of insolation of the room with different sizes and orientation of windows [8]. Our task is not set like this. It is important for us to determine the duration of insolation of the entire area of the facade of the building, and not the premises.

5. EXPERIMENTAL RESULTS

The main results were summarized in a table, which gives the distances between the facades of nine-story houses according to regulatory requirements (2 column). These indicators obtained by us as a result of our calculations and constructions for both nine-story and 12 and 18-story buildings (3 and 4 columns). As can be seen from the table, we were able to significantly reduce the gaps between the facades of houses compared with the regulatory requirements for nine-story buildings, while providing 2.5 hours of insolation. Regulatory requirements do not exist for 12 and 18-story buildings, so the data we obtained is very important for designers.

The necessary distances between the facades of multi-storey buildings. Table 1

Necessary distances	According to ShNK 2.07.01-03*, m	At the suggestion of the author, m (according to insolation rate on March 22)		
	9-storey building	9-floor house 12-	12-floor house	18-floor house
Between the long sides of latitudinal houses	40	26	35	52
Between the long sides of the diagonal houses	40	26	35	52
Between the long sides of the meridional houses	40	40	53	80
Between the long sides and ends of buildings with windows	24	26	35	52

An analysis of the density of the housing stock of buildings showed that with both latitudinal and meridional setting of houses, it is possible to achieve a high density of 8550 m² / ha (with a normative 6300 m² / ha) for 9-story buildings. During the construction of 18 storey buildings, the density of housing stock reaches 15700 m² / ha. In all cases, the recommended size of the courtyard spaces allows you to place the required number of playgrounds, recreation areas for adults, car parks, green spaces [9,10].

6. CONCLUSION AND FUTURE WORK

In the region of oases and foothills (climate zone 2), an open and semi-open structure of residential buildings should be erected with the open side of the courtyard facing the dominant direction of warm winds [11,12]. This may require the installation of diagonal houses with a long facade oriented to the NE and SW or NW and SE. What will be the duration of insolation of the facades of houses and the density of buildings with their diagonal setting?

In the desert region with frequent dusty winds, closed planning structures of courtyard spaces are preferred. In this regard, in the future it is necessary to analyze the possibility of setting meridional houses close to latitudinal. It is not known how this will affect the duration of insolation of apartments located near the adjoining houses.

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Captions to drawings.

Fig. 1. Determination of the required distances between single-section 9-story houses located latitudinally, the area of the quarter is 3.2 hectares.

House height (N) -30m, March 22. 1. The southern facade of houses 1,2,3 is insulated from 7h.30min to 16h. 30 min. 2. The western facades of 1,4,7 houses insolate from 12h.30min to 17h.30min. (5 hours). 3. The eastern facades of 3,6,8 houses are insolated from 7h.30min to 11h.30min (4 hours); 1,2,4,5,7 houses from 9h. Until 11.30 a.m. (2h 30min).

Fig. 2. Determination of the necessary distances between single-section 18-story houses and 9-story multi-section houses, the area of the quarter is 4.3 hectares.

The height of the house is 60m. 1. The southern facade of the houses, except for the first house, insolates from 7h. 30 min. Until 4 p.m. 30 min. (9 hours). The first house insolates from 7h. 30min to 15h. 2. Western facades of all single-section houses are insulated from

12h.30min. up to 15 hours (2h 30min). 3. The eastern facades of 1,2,3,4,5,7,8 houses insolate from 9h. Until 11.30 a.m. (2h 30min); 3,6,9 houses insolate from 7h.30min to 11h. 30 min.

Fig. 3. Determining the distances between multi-sectional (9 and 18-story) houses located meridionally (parallel to the north-south axis). The dashed line (option 2) shows 18 floor houses. The area of the quarter is 4.3 hectares.

The western facades of 1,2,4 houses insolate from 12h. 30 min. up to 15 hours (2 hours 30 minutes) with a gap between the facades of 40m (9et) and 80m (18et). The eastern facades of 1,3,4 houses are insolated for 2.5 hours (from 9 hours to 11 hours 30 minutes). 2. Insulation of the eastern facade of the 2nd house and the western facade of the 3rd house is optional. Therefore, the gap between the facades adopted 30m. 3. The south facade of house 5 is effectively insolated for 6 hours (from 9 a.m. to 3 p.m.), while this house does not obscure the windows of the front facade of the meridional houses at distances of 32m (9et) and 52m (18et).