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RESEARCH ARTICLE

Total Construction Duration Calculation of Public Housing Projects in Turkey: A Case Study

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Abstract

Time planning for the accurate estimation of construction duration is important to prevent construction delays and successfully complete projects on time. Although the main reasons for construction delays differ among developing countries, several factors related to project characteristics and clients contribute. In this study, interviews and observations were conducted with TOKI (Toplu Konut Idaresi-Housing Development Administration of the Republic of Turkey), a major housing construction authority in Turkey, to explore construction delays. It was revealed that TOKI uses three factors to estimate total construction duration, which are the number of flats, type of drawings utilized during the tender stage, and nonworking days. Data analysis of the TOKI Projects Status Table, which lists detailed project information for 2800 completed TOKI projects, showed that most delays occurred in housing projects. Therefore, the construction delays for TOKI housing projects were investigated in this case study. The findings revealed that there is a wide construction duration gap between calculated construction durations using TOKI's calculation method and durations indicated in official construction contracts between TOKI as a client and the awarded contractors. Therefore, it was emphasized that TOKI significantly shortened the contract duration, which ultimately resulted in delays for a considerable number of housing projects. These findings can be helpful for clients and project managers worldwide to mitigate construction delays. To effectively overcome construction delays in developing countries, suggestions are made for the need to develop accurate construction duration estimation models.

1. Introduction

The problem of delays in the construction industry is a global phenomenon owing to the extremely diverse nature of construction projects [1]. In construction, a delay refers to the time overrun either beyond the completion date specified in a contract or beyond the date that the parties agreed upon for the delivery of the project [2]. It is widely accepted that the schedule of a construction project plays a key role in project management because of its influence on the project success [3]. According to Enshassi [4], delays are among the most important factors affecting project performance. In practice, the total construction duration may exceed the calculated limits of the scheduled time because of the owner, contractor, subcontractors, or technical, legal, or natural difficulties [5].

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The major problems that construction projects face are usually because of inadequate procurement systems [6]. An unrealistic schedule when the bid duration is too short and ineffective delay-penalty provision in the contract are potential causes of delays in the total construction duration [7]. Time, cost, and quality are the three factors used to determine and measure the success of construction projects [8]. Time planning and cost certainty are the two major elements in the procurement of public construction projects [9-12]. Sufficient planning before construction is a critical requirement for project success. However, previous studies have indicated that construction projects lack sufficient planning time and effort, especially in the tender or precontract phases [10]. Increases in construction planning before implementation have been shown to have strong effects on reducing construction time [14]. Therefore, planning and programming at the tender phase are important for accurately estimating the construction duration and preventing delays. Construction projects should be scheduled, and it is important to clearly show the order and sequence of work.

Planning and programming in the tender phase are regulated by relevant laws and authorized organizations [15]. However, public construction projects in Turkey lack time planning in the tender phase [16-22] because legal regulations ignore planning and prioritize the lowest tender price [23], which situation must be improved [24-28]. Studies have also found that project duration is considered one of the least important factors in the tender phase [29,30]. It has been emphasized that lower costs should not be the only basis for choosing contractors, as time and performance factors should also be considered [31]. These findings show that the construction duration in the tender phase has not been extensively studied, although many factors have been considered in different studies. Moreover, better tender systems and effective planning specified in Development Plans have not been fully implemented [32,33].

The aforedescribed findings indicate that there is insufficient time planning for construction projects. In this study, we focus on public housing projects and the tender phase during time planning. We aim to identify the number of delays and associated delay times in construction projects, reveal the factors affecting the total construction duration, and quantify baseline construction duration (BCD) using construction documents and schematic designs.

1.1. Scope

This paper is part of a broader research which aims to develop a novel model to estimate ideal construction duration for tender stage planning in public construction projects. This case study is the first and the introductory part with sufficent details presented in scientific grounds related to the construction delays on housing projects and critics on determination of construction duration by concerned construction authority. On the other hand, the scope is limited to the planning stage of TOKI housing projects at the tender stage. Moreover, data related to scope of this study were obtained from the construction projects tendered by relevant Public Housing Laws which were published in Turkish Republic Official Gazettes.

Data used and examined for research was containing many types of construction projects such as housing, schools, hospitals, and roads. However, to construct the model, testing its applicability and ease of use for other researches in progress, it is found to be more appropriate to apply the model to project types with repetitive nature such as mass housing projects. This awareness resulted in applying the model, which will be designed to estimate “Ideal Construction Duration” in the second part of the study, only to housing projects with the highest construction delays among the others.

2. Literature review

Considering its significant contribution to the economy and development, the construction industry is an important sector in Turkey [34]. However, the most significant factor affecting project duration is cost, and many factors affecting project duration are not considered by contractors and clients such as TOKI [35]. Similar to Odabasi’s

[35] interviews with TOKI personnel, Baltaci [36] observed that the contractor's market experience, job efficacy, and environmental impacts were also considered, while no findings regarding time planning were found. Sonmez [37] emphasized that the total construction duration in the time-cost relationship for TOKI housing cannot be calculated using a single mathematical equation, and planning failures occur because of the specific characteristics of individual construction projects. Finally, Turhan [38] identified several delays due to insufficient time planning in TOKI construction projects. For these reasons, a dynamic system is required for estimating construction duration in accordance with the complex structure of TOKI projects.

Project management is based on planning and programming [39]. Construction projects are considered successful if they are completed on time, within a budget, and at a specified quality [40]. Effective planning and programming during the tender phase lead to success in the construction phase [41-43]. The most important factors affecting the time, cost, and quality of construction projects are insufficient planning and programming [44,45].

TOKI is a pioneer in the public construction sector in terms of its purpose, and it is authorized to build housing projects as a client. TOKI primarily operates within the scope of [36,46-49]. Project budgets are determined annually, and a project is suspended if there are insufficient funds at the beginning of the year. Thus, the project delivery date must be extended [50].

In planning and programming during the tender phase, the Department of Tender Affairs of TOKI prepares cost estimates for construction projects and job descriptions in contracts. Odabasi [35] observed that the contractor selection method is single-stage. Therefore, a tender process that allows the bid to be awarded directly to the eligible bidder for the jobs described in the tender requests is used. In this process, the work is awarded to the contractor with the lowest bid. The contractor is examined and analyzed by the technical committee of TOKI, and the construction firms that previously worked with the chosen contractor are asked for a reference. If the TOKI committee is convinced that the contractor is suitable for the job, it awards the project to the contractor. If the committee is not convinced, the same procedure is applied to other contractors [35]. This suggests that contracts are based on the cost and prior projects of the contractor to persuade the TOKI committee. In practice, there is no evidence related to an official calculation method for the total construction time.

Literature indicates that case studies are necessary for the analysis of the status and problems of calculating construction duration, along with a proposed model utilizing factors affecting the construction duration [51-53]. Toor and Ogunlana [6] conducted a case study of international airport construction projects. After conducting interviews and questionnaire surveys, they found that the main problems leading to construction delays were related to the designers, contractors, and consultants. The authors also emphasized the lack of resources, poor contractor management, labor shortage, design delays, planning and scheduling deficiencies, changed orders, and contractors' financial difficulties.

Lee [52] developed a probabilistic duration estimation model for high-rise structural projects. They determined that the cycle time per unit work area according to the structural method and the influence of weather were the main factors affecting the construction duration after a literature review and in-depth interviews. Their proposed estimation model divided weather variables into "weather conditions that result in nonworking days" and "weather conditions that result in work productivity rate change." Finally, a case study was conducted to validate the model, which was found to be practical, reliable, and applicable.

Jin [51] used a reasoning-based case study to estimate the preliminary duration of 83 multi-housing projects. A construction duration model was developed, and findings confirmed that the accurate construction duration estimation in the preliminary phase was enhanced by compensating for the difference between each retrieved case and the test case.

Yeom [53] conducted a case study to develop a construction estimation model using multiple linear regression during the project planning phase for office buildings in Korea. Their findings showed that the average construction duration was dependent on various factors.

Accordingly, two case studies were performed to propose construction duration models [51,53] and one case study was used to validate the proposed model [52]. Because project duration is defined by the client or suggested by the contractor [51,54], the construction duration computational model utilized by the client during the tender phase should be a specialized standard model for Turkish housing projects. To propose an ideal construction duration model for housing projects, the current situation of construction delays and time extensions should be primarily assessed. Therefore, it was concluded that the case study approach is appropriate for conducting this type of research.

3. Research methodology

This study adopted a case study methodology. According to Yin [55], a case study can be exploratory to create new knowledge, constructive to solve problems, or confirmatory to test a hypothesis with empirical evidence. The purpose of this case study was to analyze the current situation of TOKI housing projects. For this purpose, we first identified the number of delays and delay times for all types of construction projects. The average total construction duration by building type, the number of delayed and total construction projects, and the number of projects with time extensions by region were determined for both housing and other projects. A delay in construction projects is defined as exceeding the completion date specified in the contract or the date agreed upon by the parties for the delivery of the project [56]. Analysis of the TOKI Projects Status Table showed that most delays occurred in housing projects. This status table is a specific datasheet including all project data obtained by special permission from TOKI. The project information includes but is not limited to the following: “project description,” “project location,” “contract date,” “contract duration,” and “start and finish dates” on the TOKI Project datasheet. Data analyses were conducted using percentage and frequency statistics. The total number of projects was 3500; 700 ongoing projects were eliminated and 2800 projects remained. After minor data with insufficient information and projects with construction duration equals its contract duration were eliminated, 1530 housing projects were obtained.

Second, we investigated the calculation of total construction duration by conducting semi-structured interviews with TOKI officials and analyzing TOKI documents. Therefore, the approximate construction duration was formulated using data from the TOKI officials and documents. The approximate construction duration in this research refers to the total construction duration from the beginning to the end of construction during the construction phase, which is estimated in the project planning phase. To better understand the existing situation, semi-structured interviews were conducted with TOKI officials in Ankara on 22-23 December, 2015, and in Istanbul on 24-25 December, 2015. Verbal information obtained from the TOKI authorities having years of experience in high management positions was recorded in writing. No audio recordings were allowed by TOKI during data collection. During the interviews, the objectives and scope of this case study were explained. Current implementations for planning and programming in the tender phase, time allocated by TOKI personnel for completed projects, and factors used to calculate the total construction duration were discussed in the interviews. Documents, such as periodic and nonperiodic TOKI publications, were obtained. Furthermore, Supreme Court cases were examined to determine whether disputes occurred because of delays in construction duration.

Third, after formulating the BCD from TOKI, we used two different cases: durations with construction documents and with schematic design. Duration with construction documents (DCD) and duration with schematic design (DSD) were calculated and compared with the official contract durations. DCD and DSD were calculated separately, and contract duration (CD) data were used to reveal the gap between the BCD and CD.

In case studies, either primary data (data collected by the researcher) or secondary data (data from other sources) can be used. We used secondary data from TOKI officials and documents such as the TOKI Project Status Table. Two case studies were implemented according to the tender processes of TOKI.

- Case 1 – Calculation of DCD
- Case 2 – Calculation of DSD

Each case study was conducted with the intent of presenting a valid comparison of DCD/DSD versus CD. Both cases were based on 1530 housing projects. The subsequent analysis, in line with the objective of this case study, shows not only a comparison of DCD/DSD versus CD, but also a comparison with delay time (DT) for housing projects. The procedure of this study is as follows:

- Phase 1: Identification of the number of delayed projects, delay times, and number of projects with different time extensions.
- Phase 2: Identification of the construction duration factors used by TOKI.
- Phase 3: Identification of CDs and DTs from the TOKI Projects Status Table.
- Phase 4: Calculation of DCD and DSD using numerical analysis.
- Phase 5: Implementation and validation of the case study by comparing DCD and DSD with CD and DT.

The scope of this case study was limited to TOKI housing projects, planning and programming activities in the tender phase and bidding processes defined and indicated within Public Procurement Law No. 4734, No. 2985, No. 4966, No. 5162, TOKI Standard Contract for Construction, Regulation on the Use of TOKI Resources and the Regulation on Construction Tenders Implementation [47-49,57,58]. Descriptive data are limited to the TOKI Project datasheets extracted from the TOKI Projects Status Table.

4. Results

4.1. All types of projects

The findings of this study primarily involved the analysis of all types of projects constructed by TOKI within the TOKI Projects Status Table. Table 1 summarizes the average total construction durations for the different types of construction projects.

Descriptive statistics for 2800 TOKI projects were determined using the data in the TOKI Projects Status Table. There were 22 different types of projects, with most projects (1530 units) in the housing category. The average construction duration of housing projects was 486 days. Housing projects corresponded to 54.64% of the 2800 TOKI projects, followed by hospital (347 units) and school (327 units) projects. Most of the TOKI projects were executed in the Central Anatolia Region with 590 units, and the least were executed in the Mediterranean Region (238 units).

Table 2 shows that 1367 out of the 2800 TOKI construction projects in Turkey (approximately 49%) were delayed. The geographical regional distribution of projects and ratios of the number of delayed projects (NDP) to the number of total projects (NTP) were used. The ratio of the regional distribution of NDP to NTP in Turkey showed that most TOKI projects were executed in the Central Anatolia Region (21.07%) and least in the Mediterranean Region (8.50%). Projects with time extensions by region and number of extensions are shown at Table 3.

4.2. Housing projects

As a primary focus, the analysis of housing projects constructed by TOKI revealed that 720 out of 1530 housing projects were delayed. The ratio of delayed TOKI housing projects to the total number of TOKI construction projects (720/2800=0.2571) is 25.71%. The number of delayed housing projects out of 1530 TOKI housing projects was calculated as 720, and the delay rate (720/1530=0.4706) was 47.06%. These findings suggest that delays in housing projects are common among construction projects. Table 4 summarizes the average total construction duration and number of housing projects by region.

Table 1. Average total construction duration by project type

Project Type	Average Total Construction Duration (days)	Number of Projects
Housing	486	1530
Hospital	697	347
School	486	327
Building	483	142
Police Station	538	142
Infrastructure and Environmental Affairs	251	88
Dormitory	539	71
Social Reinforcement	405	49
Restoration	266	39
Stadium	722	18
University	595	16
Workplace	506	10
Sports Facility	596	4
Museum	571	3
Mosque	185	3
Container	45	3
Road	202	3
Hotel	529	2
Officers' Club	559	1
Bridge	554	1
Shelter House	554	1
Total		2800

Table 2. Number of delayed and total construction projects by region

Region	Number of Delayed Projects (NDP)	Number of Total Projects (NTP)	NDP/NTP in Region (%)	NDP in Region/NTP in Turkey (%)
Mediterranean	130	238	54.62	8.50
Eastern Anatolia	253	536	47.20	19.14
Aegean	121	260	46.54	9.29
Southeastern Anatolia	152	301	50.50	10.75
Central Anatolia	305	590	51.69	21.07
Black Sea	177	385	45.97	13.75
Marmara	229	490	46.73	17.50
Total	1367	2800	-	-

Table 3. Number of projects with time extensions by region

Regions	Number and Percentages of Projects with Time Extensions				Total Projects with Time Extensions	Percentage (%)
	1	2	3	4		
Mediterranean	107 (9.10%)	16 (11.85%)	4 (10.81%)	3 (15.00%)	130	9.51
Eastern Anatolia	209 (17.79%)	33 (24.44%)	8 (21.62%)	3 (15.00%)	253	18.51
Aegean	102 (8.68%)	13 (9.63%)	3 (8.11%)	3 (15.00%)	121	8.85
Southeastern Anatolia	119 (10.13%)	23 (17.04%)	8 (21.62%)	2 (10.00%)	152	11.12
Central Anatolia	279 (23.74%)	18 (13.33%)	6 (16.22%)	2 (10.00%)	305	22.31
Black Sea	162 (13.79%)	10 (7.41%)	2 (5.40%)	3 (15.00%)	177	12.95
Marmara	197 (16.77%)	22 (16.30%)	6 (16.22%)	4 (20.00%)	229	16.75
Total	1175	135	37	20	1367	100

Table 4. Average total construction durations and number of housing projects by region

Region	Average Total Construction Duration (days)	Number of Housing Projects
Mediterranean	450	106
Eastern Anatolia	446	271
Aegean	445	142
Southeastern Anatolia	484	139
Central Anatolia	508	370
Black Sea	474	220
Marmara	541	282
Total	486	1530

The average construction duration for housing projects was 486 days (Table 4). The Marmara and Central Anatolia Regions were above the average construction duration in Turkey with 541 and 508 days, respectively. The Southeastern Anatolia region also had an average construction duration of 484 days, which is closer to the average. Other regions had a lower total construction duration than the average.

Table 5 lists the delayed and total housing projects by region. It is significant that nearly half of the housing projects in all regions were delayed. Eastern Anatolia has the least delayed housing projects compared to other regions. Eastern regions of Turkey had higher demand for new living spaces. Therefore, authorities are paid greater attention to urbanization and political interests in these regions.

Table 6 shows that the Central Anatolia region ranks first with 181 housing projects without any time extension. However, the same region had the highest number of housing projects with one time extension. The Marmara region had the highest number of housing projects with two time extensions. The Eastern Anatolia region is the only region without three or four time extensions. Moreover, the total number of housing projects decreased between one and two time extensions from 654 to 47.

Table 5. Number of delayed and total housing projects by region

Region	Number of Delayed Housing Projects	Total Housing Projects in Region	Percentage of Delays (%)
Mediterranean	60	106	56.60
Eastern Anatolia	96	271	35.42
Aegean	64	142	45.07
Southeastern Anatolia	69	139	49.64
Central Anatolia	189	370	51.08
Black sea	104	220	47.27
Marmara	138	282	48.94
Total	720	1530	47.06

Table 6. Number of housing projects with time extensions by region

Region	Number and Percentages of Projects with Time Extensions					Number of Total Housing Projects
	0	1	2	3	4	
Mediterranean	46 (5.68%)	52 (7.95%)	5 (10.64%)	1 (10.00%)	2 (22.22%)	106
Eastern Anatolia	175 (21.60%)	85 (13.00%)	11 (23.41%)	0 (0.00%)	0 (0.00%)	271
Aegean	78 (9.63%)	59 (9.02%)	1 (2.13%)	2 (20.00%)	2 (22.22%)	142
Southeastern Anatolia	70 (8.64%)	59 (9.02%)	7 (14.89%)	2 (20.00%)	1 (11.11%)	139
Central Anatolia	181 (22.35%)	179 (27.37%)	7 (14.89%)	2 (20.00%)	1 (11.11%)	370
Black Sea	116 (14.32%)	99 (15.14%)	4 (8.51%)	1 (10.00%)	0 (0.00%)	220
Marmara	144 (17.78%)	121 (18.50%)	12 (25.53%)	2 (20.00%)	3 (33.34%)	282
Total	810	654	47	10	9	1530

From the perspective of cities, Ankara ranked first with 87 (12.08%) delays, followed by Istanbul with 59 (8.19%), and then both Bursa and Adana with 18 (2.5%) delayed housing projects.

4.3. Interviews and observations

Findings from interviews and observations suggest that the total construction duration was not calculated in line with modern project management principles. Instead, the duration estimations were based on data from previously completed projects. In addition, TOKI officials directly determine the construction duration without using any tools or software.

BCD were calculated for 1530 housing projects within the TOKI Projects Status Table by using Eq. 1, which is extracted from the calculation method used by TOKI to estimate the total construction duration for housing projects:

$$\begin{gathered} BCD = DCD + \textit{nonworking days} \\ \text{or} \\ BCD = DSD + \textit{nonworking days} \end{gathered} \tag{1}$$

where if schematic design will be used, DSD=DCD+50 (days); DCD is the duration for construction designs which are described as drawings that are created as the final product after the entire design phase is completed and in which the deficiencies are minimized; DSD is the duration for schematic designs which are described as incomplete drawings have deficiencies that need to be completed in terms of design and cannot be used directly in production. Both DCD and DSD are fundamentally depend on the number of flats for the relevant project. Interviews and formal correspondences with TOKI indicated that in case of beginning the tender with the DSD in housing projects, the total construction duration is extended by an amount of 50 days. This extension for housing projects is determined by TOKI itself due to the fact that in order to start production, the contractor has to turn construction documents into detailed schematic projects after carrying out the design work for a certain period of time on the preliminary projects.

Therefore, three factors were used to estimate the total construction duration of TOKI projects. However, Supreme Court case law indicates that there are legal disputes due to time delays related to housing projects tendered by TOKI in Turkey [59-63]. Many conflicts generally arose from delays in the project delivery dates specified on the contracts. The claims showed that houses were not delivered to beneficiaries on contract dates. Therefore, the three factors used by TOKI to estimate total construction duration were inadequate, and TOKI needs to consider additional factors to estimate the total construction duration more accurately to prevent conflicts between parties. The literature also indicates these findings suggesting that modern planning and programming techniques, rather than utilizing data from previously completed projects, should be used for construction projects [9,35,66].

The findings of the Supreme Court cases and interviews also showed that particularly inexperienced and willing contractor companies that are new to the market are not required to perform detailed planning during the tender phase. Consequently, both time extensions and other disputes are emphasized in civil lawsuits arising from delays in construction projects awarded by TOKI. The Supreme Court's law case emerges as further evidence for the existence of the problem resulting from lack of time planning at the tender phase.

4.4. Two cases

4.4.1. Case 1: Calculation duration with construction documents (DCD)

In the last phase of this case study, the baseline DCDs and DSDs were compared with the CDs and DTs for housing projects.

In Table 7, the differences were found to be positive for 62.71% of the housing projects by subtracting CD from DCD. There are four construction projects with "DCD-CD=0" out of 1534 housing projects. The results with zero-values were not included in the analysis. All calculations were made with a sample of 1530 housing projects. A positive value indicates that the DCD values are higher than the CD values. In this case, it was determined that the DCD obtained from the total construction duration calculated by TOKI was usually longer than the CD duration, and it was shown that TOKI considerably shortened the total construction duration in official contracts. Therefore, the total construction durations were shown to be shorter than they should be for nearly 63 out of 100 housing projects.

First, the CD values were subtracted from the DCD values (Table 7). This difference showed the extent to which TOKI authorities shortened the construction duration in construction contracts. Second, the contract date was subtracted from the project completion dates to find DT. Third, (DCD-CD) values were subtracted from the DT values, resulting in 71.34% positive values. A positive value for 71.34% of housing projects indicated that the shortening of the total construction duration by TOKI officials was higher than the delays. In other words, the magnitude of the shortened duration was generally higher than the DT in housing projects. Even if delay margins were added to the CD for a housing project, the DCD value could not be reached. This shows the considerable magnitude of the shortenings made by TOKI during the tender phase. This major difference implies that the CD determined by the TOKI has low reliability. It is clear that delays in the total construction duration will lead to more prosecutions against contractors than against TOKI.

Table 7. Comparisons of DCD, CD, and DT

	Durations	Values (%)
Comparisons of DCD with CD	DCD-CD<0 (Negative)	37.29
	DCD-CD>0 (Positive)	62.71
Comparison of (DCD-CD) with DT	(DCD-CD)-DT<0 (Negative)	28.66
	(DCD-CD)-DT>0 (Positive)	71.34

[a]DCD: Duration with Construction Documents; CD: Contract Duration; DT: Delay Time.

4.4.2. Case 2: Calculation duration with schematic design (DSD)

To calculate the DSD, the DCD was first determined according to the number of flats in Equation 1. Afterwards, 50 days were added to the DCD value, DSD was calculated, nonworking days were added, and the final DSD values were determined according to the location of the project.

In Table 8, the differences between CD and DSD were found to be positive for 76.80% of housing projects. The results with zero-values were neglected. Positive values indicated that the DSD values were higher than the CD values for the majority of housing projects. In this case, it was also determined that the DSD obtained from the total construction duration calculated by TOKI was usually longer than the CD duration, and it was shown that TOKI considerably shortened the total construction duration in official contracts. Therefore, the total construction durations were shown to be shorter than they should be for nearly 77 out of 100 housing projects.

First, the CD values were subtracted from the DSD values, as shown in Table 8. This difference shows the extent to which the TOKI authorities shortened the construction duration and used it in construction contracts. Second, the contract date was subtracted from the project completion dates to find DT. Third, DSD-CD values were subtracted from the DT values, resulting in 75.39% positive values. A positive value indicates that the shortening of the total construction duration by TOKI officials was higher than the delays. Therefore, the magnitude of the shortened duration was generally higher than the DTs in housing projects, similarly to DCD. Even if delay margins were added to the CD for a housing project, the DSD value could not be reached. This shows the magnitude of the shortenings made by TOKI during the tender phase. This major difference also implies that the CD determined by the TOKI has low reliability. It is obvious that delays in the total construction duration will lead to more prosecutions against contractors than against TOKI.

5. Discussion and Conclusions

This study revealed that 720 among a total of 1530 housing projects were delayed (rate of 47.06%). The ratio of delayed housing projects to all TOKI projects was 25.71%. The results of the case study analysis for the TOKI housing projects showed that the DCD values were evidently higher than the CD values. Therefore, it was determined that the CD values were considerably shortened by TOKI for the calculation of the total construction duration. Similarly, as a result of the comparison of (DCD-CD) with DT, positive values were obtained in excess amounts of TOKI projects, and it was observed that the magnitude of the shortened duration was generally higher than the delays in housing projects. These findings suggest that the shortening of the CD is considerably high. Greater shortening of CD also caused contractors to deliver more delayed projects to stakeholders.

Consistent with the existing literature, imposing of unrealistic CDs and improper planning are common among contractors, clients, and owners [1,8,11]. Yeom [53] found that the average construction duration for 47 cases was approximately 901 days with a standard deviation of 301 days. Although these cases included both apartments and office buildings, similar to our study, their results were remarkably different from ours, which may indicate the magnitude of duration shortening by TOKI.

Table 8. Comparisons of DSD, CD, and DT

	Durations	Values (%)
Comparisons of DSD with CD	DSD-CD<0 (Negative)	23.20
	DSD-CD>0 (Positive)	76.80
Comparison of (DSD-CD) with DT	(DSD-CD)-DT<0 (Negative)	24.61
	(DSD-CD)-DT>0 (Positive)	75.39

[a]DSD: Duration with Schematic Design; CD: Contract Duration; DT: Delay Time

Other case studies suggested the development of construction duration models such as Building Information Management (BIM) to improve the planning and realization of construction projects [10,64,65]. One of these case studies demonstrated a duration reduction by 67% from the contract duration [64]. Further findings showed consensus on the requirement for advanced engineering management tools to increase the probability of completing a project within or below its time horizon [13].

There are several limitations to this study. First, the data used to calculate construction durations, delays, and time extensions are owned by TOKI. Second, two of the investigated cases involved only public housing projects because the majority of projects are public housing projects and they incur major delays. Third, the reliability of the conclusions to be drawn from the research findings depends on the respondents. To overcome this limitation, we chose high-ranking and experienced personnel to ensure the quality of this research. Our results can only be generalized for public housing projects because several other factors can affect the calculation of the construction duration.

In conclusion, it was shown that the three factors used by TOKI to calculate the total construction duration were insufficient. TOKI officials determined the official CD by significantly shortening the BCD through the consideration of these three factors. This study found that this shortened duration was excessive as many housing projects were delayed, and these delays led to time and cost losses for all project stakeholders. Therefore, a model that calculates the ideal construction duration and considers additional factors affecting the total construction duration should be proposed.

Declaration

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Author Contributions

H. Tıratacı: Conceptualization, Methodology, Validation, Formal Analysis, Writing-Original draft, Writing- Review & Editing; H. Yaman: Conceptualization, Methodology, Data Curation, Writing- Review & Editing, Visualization, Supervision

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Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Ethics Committee Permission

Not applicable.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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