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INCREASING DEMANDS FOR NATURAL STONES USAGE AROUND THE WORLD

Hasan Üçpırtı[1] Zeki Gündüz[1]

İnşaat Mühendisliği Bölümü, Sakarya Üniversitesi, Esentepe Kampüsü, Adapazarı[1]

Abstract – Due to great demands in construction business, the stone industry has been growing very fast around the world. In fact, the technological improvements on the machinery of marble and granite processing plant and quarry in recent years gives impulse to the stone business. According to studies reported, there are recognizable increments on both productions and constructions. Natural stones become driving forces in the countries economy. In this study, some statistical numbers for productions and consumption of natural stones will be presented in a base of countries that strongly involve in stone business. The importance of the economical impacts of natural stone on countries economy will be emphasized. Then, the future of natural stones and its business will be discussed.

I. INTRODUCTION

The usage of homogenous and compact stones, that can be easily polished, can be traced through thousands of years of civilization. In the 19th century, the amount of marble consumed generally increased. Until our own century, which was the first to see industrialization introduced to marble processing, marble was used not only as a decorative element and as wall-facing but also for it structural capacities[1].

The increasing demands to natural stones such as marble and granite, caused to open new quarries all around the world. In a small period of time, small or big hundreds of marble and granite quarries private or state owned have been operated[2]. In 1996, 94 million tons of marble and stone materials were produced world-wide and 500 million square meters were used for cladding and paving. The turnover of the stone industry was 20 billion dollars, representing an increase in consumption of 9.7% compared to the previous years[3].

Even though natural stone business is a risky business, either natural stone quarries or processing plants are drastically increasing. According to government source, the most successful branch in mining is marble sector. During previous 10 years, export rate reached 90% of the whole production amount. This does not mean that there are no problems in marble business. Despite of it is getting better when it is compared with previous years. However, natural stone trading becomes very tuff in recent years [4].

II. PRODUCTION OF NATURAL STONES AROUND THE WORLD

The production of the world's natural stones in 1995 was totally 39.1 million tons. When the comparison is made with the previous year, 1994, it can be seen the continuing upward growth trend, up 3.2% from the 3.7%. European countries remain the world's leading manufacturers. They produce almost 57% of world output. European production was only slightly up, with four of the well-known producer countries in the European Union (EU) - Portugal, Spain, Greece and Finland – will showing less than 1% increases, while Italy maintained output close to levels seen over the previous years. Even though Italy is returned its position as the world's leading producer of 7.5 million tons, its sharing in market slightly declines to 19.2% in 1995. In general, some former East Bloc countries such as Bulgaria, the Czech Republic, Romania and Russia are recovering[5].

In 1995, there is a mixed output trends in South American countries. While Brazil's production is 6% up, Mexico's production fell drastically by approximately 40%. In North American countries, the US production is slightly increased while Canada's production is its previous position. In this region, there is significant

production potential. Both countries are looking for opening new quarries. Since there is a great interest to use natural stones as opposed to alternative materials that have been dominated in the past[5].

As it seen in 1994, Turkey was showed a significant increase in production, up to 20%, 1.2 million tons. In Asia, India has the highest increase at 12%. The other South East Asia country such as Malaysia, Indonesia and Thailand continued their upward trends. Production in Taiwan and China was steady. Output in Japan and South Korea felt by 5% and 10% respectively. In 1995, European countries were dominating in the world stone production with 56.9%. This is more than the half of the world stone production. Also, production of granite was increased from 19% to 40% in 19 years. At the same time, production of marble was decreased from 76% to 55%. Production of the other natural stones was remain same in 19 years. As a result, there have been an increasing demand for granite during the last two decades. According to the world stone report, 1996, the world stone production by country (1995) is given in Table 1. It is remarkable to note that Turkey does not exist in Table 1[5].

Table 1. World Stone Production by Country (1995)[5].

Country	Production (000 tons)	%
Italy	7,500	19.2
China	5,000	12.8
Spain	3,500	9.0
Greece	2,050	5.2
India	1,800	4.6
Brazil	1,700	4.3
France	1,500	3.8
South Korea	1,400	3.6
USA	1,400	3.6
Portugal	1,300	3.3
Sub Total	27,150	69.4
Others	11,950	30.6
World Total	**39,100**	**100.0**

III. CONSUMPTION OF NATURAL STONES AROUND THE WORLD

As technical improvement, the different characteristics of various marbles, granites, travertine and the other natural stones become available for construction business. With regard to the building application of natural stones, stones are classified in four categories as commercial materials:

a) Marble, b) Granite, c) Travertine and d) The other stones [3].

The construction business is still the largest user of granite products, accounting for 75 % of total consumption. Granite is mainly used for cladding, flooring and interior decorative due its multi-colored variation. 15 % of granite consumption is in the monument and tombstone industry. Japan is the leading country with 40 % of total. In different part of country, different kind of granite are more popular[5].

During 1995, consumption of natural stone reflected the mixed economic fortunes in the world's leading consuming nations. In Europe, demand for natural stone become static. However, only Turkey (up 15 %) and Portugal (up 10 %) showed some meaningful increment. In Asia, China (up 20 %) and India (up 11%) are evident of for the increment of the consumption. There is a slight increment in North America. These countries are expected to show continued growth with a different speed.

In 1995, 63 % of the World natural stone consumption is done by the 10 leading consuming countries. As in the past, 37 % of the world natural stone consumption is occupied by European countries such as Italy, Spain, Germany, Greece and France. Italy remain the industry's largest consumers of natural stone product at 6.3 million tons. China is the second country with 3.0 million tons of natural stone products. It seems world stone consumption is heading for some sort of structural diversification due to the growth in the Far East markets beside the European markets which has already have a great demand. In both China and India, domestic markets are demanding. The emergence of Taiwan and South Korea as major granite processing nations could still place the leadership of Italy under pressure in years to come[5].

The significant end-uses of granite and sandstone in 1995 is tabulated in Table 2. Flooring and external facing are the leading application area for the natural stones. In Table 3, the apparent consumption in the world stone industry in 1995, is demonstrated. Italy is the leading country in total production and both export and import. In 1995, the total production of Turkey is 1,200,000 tons. The world stone trade-export by country in 1995 is given in Table 4. Again, Italy is in the first place in total stone. China is in the first place in granite with 1,154,000 tons. In Table 5, the world stone trade-import by country is illustrated. In the total stone import, Italy is the leading country again. But, Japan is following Italy with a small difference. In the granite import, the

leading country is Italy. Taiwan follows Italy with 1.198.000 tons of import of granites[5].

Table 2. Significant End-Uses Granite + Sandstone (1995)[5].

Classes	Equivalent m^2 (000)	000 tons	%
Flooring	54,900	3,000	36.8
External Facing	29,300	1,600	19.6
Stairs and Similar	8,250	450	5.5
Structural Works	12,000	650	8.0
Internal Facing	7,500	400	4.9
Special Works	10,200	550	6.7
Funeral Trade	22,500	1,200	14.7
Other Uses	5,550	300	3.7
Total	**150,200**	**8,150**	**100**

Table 3. Apparent Consumption in the World Stone Industry (1995)[5].

Country	Prod.	Exp.	Imp.	Appar.	%
Italy	7,500	3,127	1,965	6,338	16.2
China	5,000	2,049	96	3,047	7.8
Spain	3,500	1,023	492	2,969	7.6
Japan	400	-	1,868	2,268	5.8
USA	1,400	284	722	1,838	4.7
France	1,500	169	480	1,811	4.6
Greece	2,050	318	-	1,732	4.4
Taiwan	350	49	1,376	1,677	4.3
Germany	600	236	1,138	1,502	3.8
S. Korea	1,400	223	309	1,486	3.8
Brazil	1,700	723	-	977	2.5
Turkey	1,200	273	-	927	2.4
Portugal	1,300	464	78	914	2.3
India	1,800	1304	-	496	1.3
S. Africa	754	667	-	87	0.2
Others	8,650	1,912	4,297	11,035	28.2
Total	**39,104**	**12,821**	**12,821**	**39,104**	**100.0**

IV. ECONOMICAL IMPACTS OF NATURAL STONES

Natural stones are the drilling forces in the world economy. In 1996, 94 million tons of marble and stone materials were produced world-wide and 500 million square meters were used for cladding and paving. The turnover of the stone industry was 20 billion dollars, representing and increase in consumption of 9.7 % compared to the previous year. 17 million tons of natural

Table 4. World Stone Trade-Exports by Country (1995)[5].

Country	Total Stone		Granite	
	(000 tons)	%	(000 tons	%
Italy	3,127	24.4	178	2.9
China	2,049	16.0	1,154	19.0
India	1,304	10.2	1,039	17.2
Spain	1,023	8.0	519	8.6
Brazil	723	5.6	638	10.5
S. Africa	667	5.2	667	11.0
Portugal	464	3.6	141	2.3
Greece	318	2.5	-	0
USA	284	2.2	210	3.5
Finland	283	2.2	262	4.3
Others	2,579	20.1	1,250	20.6
Total	**12,821**	**100.0**	**6.058**	**100.0**

Table 5. World Stone Trade-Imports by Country (1995)[5].

Country	Total Stone		Granite	
	(000 tons)	%	(000 tons	%
Italy	1,965	15.3	1,645	27.2
Japan	1,868	14.6	821	13.6
Taiwan	1,376	10.7	1,195	19.7
Germany	1,138	8.9	325	5.4
USA	722	5.6	118	1.9
S. Arabia	502	3.9	10	0.2
Spain	492	3.8	276	4.6
France	480	3.7	244	4.0
Hongkong	358	2.8	44	0.7
Belgium	326	2.5	160	2.6
Others	3,594	28.0	1,220	20.1
Total	**12,821**	**100**	**6.058**	**100**

stone and marble were imported/exported. Most of the stone products were in the form of finished stone rather than raw material. The 44 % of the used marble and stone materials were used in countries different from the producing one. This indicates how the stone industry has became a fully global business and has an economical impact on country's economy [3].

There is a great demand for natural stones in the United States. The U.S's natural stone export from different country is increasing every year. However, this increment is not enough for this kind of important and big market. On May 1995, total marble import of the

U.S. was 20,908,825 $ (25,608 tons). On may 1996, total marble import of the U.S. became 23,514,475 $ (26,628 tons). When one looks at those numbers and Turkey's import to the U.S. on May 1996 (603,807 $), it is possible to say that this is low number. On the other hand, Italy which is the leader of the world natural stone exported 1,380,018 tons (11,256,231$) of marble to the U.S. on May 1997.Beside this, Italy already exported 6,534 tons (7,598,478 $) of granite and 40 tons (108,371 $) of the other natural stones to the U.S. Even though Turkey owns one of the biggest resource of natural stones, the natural stone exports to the U.S. does not reflect Turkey's real position. If one looks into the reality, Turkey is young and un-experience country in the natural stone industry. After some times, Turkey can compute with the other country such as Italy, Spain and etc. in every stone market. It is better to keep in mind, America is one of the biggest and promising country for natural stone export[6].

V. FUTURE PROSPECTS OF NATURAL STONES

In the construction industry, ceramic products are the major competitors of natural stones. The consumption of ceramic tiles is four times higher than of natural stone products such as marble and granite. It is unlikely that ceramic products will replace dimension stone products in application such as memorials and the external cladding of buildings. For interior decorative of the buildings, It may possible to see increased consumption of natural stone in markets previously dominated by ceramic. Any major inroad by granite into the ceramics market could see the worldwide use of natural stone increase 40 % by the year of 2000 [5].

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STOKASTİK, MİNİMUM ZAMANLI, ARALIKLI TAŞIMA PROBLEMİ

Mehmet AHLATÇIOĞLU[1] **Mustafa SİVRİ**[2]

1 Yıldız Teknik Üniversitesi, Fen-Edebiyat Fakültesi Matematik Bölümü Yıldız/İSTANBUL
2 Yıldız Teknik Üniversitesi, Kimya-Metalurji Fakültesi Matematik Müh. Böl. Yıldız/İSTANBUL

Özet-Taşıma zamanı stokastik olduğunda, aralıklı taşıma problemine zaman-fiyat etkileşimine bağlı olarak bir çözüm önerilmiştir. Aralıklı taşıma problemi aşağıdaki şekilde tanımlanır:

Depolarda taşınacak mallar sabit, fakat talep merkezlerindeki taleplerin bir alt sınır, bir de üst sınırı vardır.

Abstract-When transportation time is stochostic, a solution is proposed depending on a time-cost tradeoff for the interval transportation problem. The interval transportation problem is defined as follows:

The goods transported in the warehouse are constant but demand centers have lower and upper bounds.

1. GİRİŞ

Modelin Elemanları

Bilinenler:

m : depo sayısı

n : talep merkez sayısı

a_i : i . depodaki mal miktarı

b_j^- (b_j^+) : j. merkezdeki talep miktarının alt ve üst sınırı

c_{ij} : i den j ye birim taşıma fiyatı

μ_{ij} : i den j ye ortalama taşıma süresi

σ_{ij} : i den j ye taşıma süresindeki standart sapma

Parametre:

K_α : F(.), Normal dağılım eğrisinin kümülatif fonksiyonu ve α olasılık parametresi olmak üzere

$$F(K_\alpha)=\alpha \geq 0.5$$

şeklinde tanımlanmıştır.

Aranan:

x_{ij} : i den j ye taşınacak miktar

Amaçlar:

Öncelikli Amaç: Taşımanın minimum sürede yapılması

İkincil Amaç : Taşımanın minimum fiyatla yapılması

Kısıtlar:

Depo kısıtları: Bütün depolardaki malların taşınması

Talep merkezi kısıtları: Merkezlerdeki talebin alt ve üst sınırlar arasında tatmin edilmesi

Pozitif kısıtlar: Taşınacak miktarların ve taşıma sürelerinin pozitif değer alması

Modelin Matematik Yapısı

Amaçlar:

Öncelikli Amaç :

$$\min \left\{ \max_{i,j} t_{ij} \,\middle|\, x_{ij} > 0 \right\} \qquad (1)$$

İkincil Amaç :

$$\min \sum_i \sum_j c_{ij} x_{ij} \qquad (2)$$

Kısıtlar:

Depo kısıtları:

$$\sum_j x_{ij} = a_i, \quad i = 1, \ldots, m \qquad (3)$$

Talep merkezi kısıtları:

$$b_j^- \le \sum_i x_{ij} \le b_j^+, \qquad j = 1, \ldots, n \qquad (4)$$

Pozitif kısıtlar:

$$x_{ij} \ge 0, \quad (i = 1, \ldots, m \quad j = 1, \ldots, n) \qquad (5)$$

II. ALGORİTMA

Stokastik minimum zamanlı, aralıklı taşıma problemini adım-adım çözüp, alternatif çözümler öneren algoritmamız aşağıdaki sırada verilmiştir.

Adım 0: N=m.n tane $t_{ij}=\mu_{ij}+K_\alpha\sigma_{ij}$ doğrularının ikişerli kesişimleri ile bulunan $\left(\binom{N}{2}\left(C_N^2\right)\right)$ tane elemandan non-negatif K_α değerleri, t_{ij} lerdeki sıralamaları değiştiren değerlerdir. Bu sebeple $K_\alpha \ge 0$ değerlerine $[0,\infty)$ aralığının kırılma noktaları denir. K_α lar arasında oluşan bu aralıkların her birindeki t_{ij} lerin sırası değişmez. Bu nedenle içerisindeki herhangi bir noktayı K_α nın temsilcisi olarak seçebiliriz. Ancak aralıklar değiştiğinde t_{ij} 'ler arası sıra değişir. Bunun için incelemelerimizi her bir aralık için ayrı ayrı yapacağız.

Adım 1: $\left[K_{\alpha_{l-1}}, K_{\alpha_l}\right]$ $(l=1, 2, \ldots)$ aralıklarını oluştur,ve her bir aralık için K_{α_l} aralik temsilcilerini belirle.

Adım 2: $\left[K_{\alpha_{l-1}}, K_{\alpha_l}\right]$ aralığında $t_{ij}^l = \mu_{ij} + K_{\alpha l}\sigma_{ij}$ stokastik taşıma sürelerini belirle. Taşıma süresinin bir alt sınırı

$$t_p^l = \max\left\{ \max_i \min_j t_{ij}^l, \ \max_j \min_i t_{ij}^l \right\}$$

dir. t_p^l den büyük ve farklı zamanları $t_p^l < t_{p+1}^l < t_{p+2}^l \ldots$ şeklinde küçükten büyüğe sırala.

Adım 3: $t_{ij}^l \le t_p^l$ olan gözleri atamaya aç. Uygun atama yapabilmek için, elemanları

$$M_{ij}^{l_p} = \begin{cases} \min(a_i, b_j^-) & t_{ij}^l \le t_p^l \\ 0 & t_{ij}^l > t_p^l \end{cases}$$

olan $[M_{ij}^{l_p}]$ (i=1, ..., m; j=1, ... ,n) atamalar matrisini oluşturalım. Taşıma problemine uygun bir çözüm olması için bütün arzların karşılanması koşulu

$$\sum_{j=1}^{n} M_{ij}^{l_p} \ge a_i : \qquad i = 1, \ldots, m$$

bütün taleplerin alt sınırlarının karşılanması koşulu

$$\sum_{j=1}^{m} M_{ij}^{l_p} \ge b_j^- : \qquad j = 1, \ldots, n$$

şartları birlikte gerçeklenmelidir. Gereklilik koşulu gerçeklenirse $\left[K_{\alpha_{l-1}}, K_{\alpha_l}\right]$ aralığındaki stokastik sürenin yeterliliği için Adım 4'e geç.

En az bir gereklilik koşulu bile gerçeklenmezse t_p^l den bir büyük taşımcı süreli gözlerinde taşımaya açmak için p=p+1 al ve Adım 3'e dön.

Adım 4: *l*. alt problem için

$$C_{ij}^{l} = \begin{cases} c_{ij} & t_{ij}^{l} \le t_{p}^{l} \\ M & t_{ij}^{l} > t_{p}^{l} \end{cases}$$

taşıma fiyat matrisi oluşturulur. Burada M sonsuz mertebesinde büyüktür. Dolayısıyla taşımaya açılmamış gözlere atama yaptırmaz.

C_{ij}^{l} fiyatlarıyla yapılan taşıma problemi iki aşamada çözülecektir.

1. Aşama : Bu aşamada talep merkezlerinin alt sınırları, minimum maliyetle tatmin edilecektir.

Bunun için (2) amacı; (3), (4) ün sol yanı ve (5) kısıtları altında optimize edilir. Yani, talebin alt sınırlarına göre kurulmuş taşıma problemi, yapay talep merkezi ilavesi ile dengeli hale getirilir. Eğer problemin çözümü yok ise t_p^l den büyük taşıma süreli gözleri taşımaya açmak için p=p+1 al ve adım 4' e dön. Optimal çözüm bütün merkezlerdeki talebin alt sınırlarını tatmin eder. Yapay talep merkezlerine (p+1). sırayı verirsek i depodan yapay talep merkezine atanan miktar $X_{i,n+1}^{(1)}$ ile gösterilecektir. Gerçekte bu miktar i.ci depoda kalmıştır. Bunun için bütün depolardan yapay talep merkezlerine yapılan birim taşımcı ücretleri sıfır alınmıştır.

2. Aşama: 1. aşamada yapılan taşımadan sonra depolardaki kalan mallar ile talep merkezlerinin ilave taleplerini yeniden belirleyelim.

1. Aşamanın optimal Çözümü :

$X_{ij}^{(1)}$ i. inci depodan j. inci talep merkezine taşınan miktarı göstersin.

$a_i = X_{i,n+1}^{1}$; i. inci depoda kalan mal miktarı

$b_j = b_j^{+} - \sum_{i=1}^{m} X_{ij}^{(1)}$: j. inci merkezde kalan talebin üst sınırı

Amaç : $\min z = \sum_i \sum_j C_{ij}^{l} x_{ij}$

Kısıtlar :

$$\sum_j x_{ij} = a_i$$

$$\sum_i x_{ij} = b_i$$

$$x_{ij} \ge 0$$

Problemin optimal çözümü yok ise p=p+1 al ve

$$C_{ij}^{l} = \begin{cases} c_{ij} & t_{ij}^{l} \le t_{p}^{l} \\ M & t_{ij}^{l} > t_{p}^{l} \end{cases}$$

oluştur ve adım 4'e dön. Eğer problemin optimal çözümü $X_{ij}^{(2)}$ (i = 1, ... , m j = 1, ... , n) ise ,aralıklı taşıma probleminin optimal çözümleri.

$$X_{ij}^{*} = X_{ij}^{(1)} + X_{ij}^{(2)}$$

öncelikli amaç değeri, $t_p^{*} = t_p^{l}$

İkinci amaç değeri, $Z_l^{*} = \sum_i \sum_j C_{ij}^{l} x_{ij}^{*}$ olmak üzere

l. aralıkta optimal çözüm (Zaman-Maliyet) ($t_p^{*} = Z_l^{*}$) dır.

Adım 5: Eğer bütün aralıklar bitmedi ise bir sonraki aralıktaki çözüm için *l*=*l*+1 al ve adım 2'ye dön.

Adım 6: Bütün aralıklar bitti ise dur. Tüm çözüm takımları elde edilmiştir.

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