

**BENEFICIAL UTILIZATION OF USED FOUNDRY SANDS AS
CONSTRUCTION MATERIALS**

By

Tarun R. Naik
Director, Center for By-Products Utilization

Dhaval M. Parikh and Mathew P. Tharaniyil
Research Assistants, Center for By-Products Utilization

Department of Civil Engineering & Mechanics
College of Engineering and Applied Science
University of Wisconsin - Milwaukee
P.O. Box 784, Milwaukee, WI 53201
Telephone: (414) 229 - 6696
Fax: (414) 229 - 6958

Beneficial Utilization of Used Foundry Sands as Construction Materials

Tarun R. Naik¹, Dhaval M. Parikh², and Mathew P. Tharaniyil²

Abstract

This research was conducted with a view to evaluate the performance of concrete masonry blocks containing discarded foundry sand as a replacement of fine aggregate. A control mortar mix for block was proportioned to achieve a 28-day compressive strength of 1500 psi (on the basis of gross area). Other mixes were also proportioned to replace 35% of regular concrete sand with used foundry sand by weight on one on one basis. The performance of blocks were evaluated with respect to compressive strength, water absorption and bulk density, as per ASTM standards. Blocks made using different foundry sands showed variation in their properties. Technical feasibility of utilizing discarded foundry sand up to 35% replacement level in manufacturing masonry blocks has been established with this research.

Introduction

During the 1970's and 1980's, federal and state environmental agencies began to pay increasing attention to industrial pollution, safety and waste management control. As a result, the foundry industry had to re-evaluate standard practices with regard to the disposal of their used sands. One of the main concerns for the foundry industry has been the need to reduce the disposal cost and minimize the maintenance cost of landfill sites. This was mainly because of the passage of the Public Law 94-580, the Federal Resource Conservation and Recovery Act of 1976, which is a nationwide program that regulates and manages by-product disposal (1). The Hazardous and Solid Waste Amendments of 1984 made the Resource Conservation and Recovery Act (RCAA) even more stringent. Shrinking landfill space throughout the United States has caused landfill operators to refuse used foundry sand on the basis of high volume and "special waste" status. Also the disposal sites accepting used foundry sand charge relatively high tipping.

The typical amounts of total by-product material from foundries range between 500 to 5000 pounds per ton of produced metal casting (2). The foundry by-products disposal is one of the major concerns to the eastern and midwestern states, as they have the maximum number of foundries. According to Wisconsin Department of Natural Resources, Solid Waste Section, over 580,000 tons of foundry by-products were landfilled in 1987, in Wisconsin.

¹ Director, Center for By-Products Utilization, Department of Civil Engineering and Mechanics, UWM, P.O. Box 784, Milwaukee, WI 53201.

² Research Assistants, Center for By-Products Utilization, Department of Civil Engineering and Mechanics, UWM, P.O. Box 784, Milwaukee, WI 53201.

Scope

The objective of this research was to study the feasibility of beneficial utilization of used foundry sand, in the manufacturing of concrete masonry blocks; as a partial replacement of regular sand.

An extensive literature search was undertaken and detailed tests were conducted per ASTM C33, on by-product samples to determine their physical properties and to evaluate their possible uses.

Five mixes were proportioned to replace 35% of regular concrete sand with both used and clean/new foundry sand to manufacture small size concrete masonry blocks in the laboratory. These blocks were then tested for compressive strength, bulk density, and water absorption.

Overview of Foundry Sands

Sand is used in this foundry industry mainly for making molds for the casting. This sand is generally recycled. After a repeated use, they lose their characteristics and thereby becoming unsuitable for further use in manufacturing process. This sand is usually discarded and dumped in the landfill as a waste. The following section briefly discusses the different types of used foundry sands.

Molding Sand

Molding sand is typically compacted around a pattern similar to the casting that is to be produced. After the pattern is removed the molten metal is poured into the cavity to produce a casting. Different types of molding sands are used in the foundry industry; the most common being green sand (3).

Commonly used green sand is composed of sand, clay, sand additives and water. This sand usually comprises about 50 to 95 percent of the total material in a molding. Clay acts as a binder for green sand. Clay forms approximately 4 to 10% of green sand mixture. Carbonaceous materials make up 2 to 10 percent of the green sand mixture. The selection of a carbonaceous material depends on the specific property or properties described in the molding sand; like surface finish, easier cleaning, etc. The final additive of green sand is water.

Other types of molding sands include dry sand molding, loam-molding and hard sand molding. Hard sand molding process involves use of silica sand with a chemical binder system to form bonds between the individual sand grains thereby producing a hard sand mold.

Core Sand

Core sands are used to produce internal cavities which are not practical to produce by normal molding process. Core sands are composed essentially of silica sand mixed with small amount of binder.

The binders, used for core sand, can be either organic type or nonorganic type. Organic binders include oil, synthetic, cereal proteins, pitch and wood flour binders. Most of the organic binders used are synthetic binders. Bonding properties are increased by the use of catalysts. Core sand mixture, which uses a liquid catalyst for curing is commonly referred as nobake sand.

All types of core sand binders will diminish either partially or completely when exposed to heating during molten metal pouring. The by-product that result from the core sand is called core butts. Core butts can be crushed and recycled back into the molding sand process, or may be taken directly to the landfill for disposal along with broken or off-specification cores and core room sweepings.

Cleaning Room Sand

After the castings are made, they are cleaned to remove sands and metal protrusions. The cleaning room sand includes grinding material and steel shots which are used to smoothen the surface of the casting. Grinding materials consist of silica, silicon carbide alumina and small amounts of binder.

Furnace or Cupola Dust

Furnace or cupolas emit a large amount of exhausts carrying suspended dust particles. These are collected by the air pollution control devices and are called cupola dust.

Laboratory Investigation

Materials

Cement

Type I cement obtained from LaFarge Corporation was used in this testing program. The chemical composition of the cement was studied using x-ray fluorescence. The results are shown in Table I.

The physical properties of Type I LaFarge Cement were also determined in the laboratory in accordance with ASTM C150. The temperature and relative humidity in the laboratory were maintained at $68^{\circ}\text{C} \pm 3^{\circ}\text{F}$ and $42 \pm 5\%$ respectively. The following tests were conducted:

- (a) Air Content (ASTM C185)
- (b) Fineness by Blain Air Permeability (ASTM C204)
- (c) Soundness (ASTM C151)
- (d) Specific Gravity (ASTM C188)
- (e) Compressive Strength of Hydraulic Cement Mortar (ASTM C109)
- (f) Initial and Final Setting Time, Vicat's Apparatus (ASTM C191)

The results of these tests are shown in Table II.

Aggregates

The coarse and fine aggregates used in this research program were obtained from a local ready mix company. The coarse aggregate was a mixture of crushed and rounded gravel with maximum size of 3/8". The fine aggregate was natural sand with a 1/4" maximum size. All the ASTM C33, Standard specification for concrete aggregate, were conducted to determine the physical properties of the aggregates.

- (a) Moisture Content (ASTM C566)
- (b) Unit Weight and Volume of Voids (ASTM C29)
- (c) Specific Gravity and Absorption (ASTM C127 for C. A) and (ASTM C128 for F.A.)
- (d) Sieve Analysis and Fineness Modulus (ASTM C136)
- (e) Material Finer than #200 (75 μ m) Sieve (ASTM C117)
- (f) Clay Lumps and Friable particles (ASTM C142)
- (g) Organic Impurity for Fine Aggregates (ASTM C40)
- (h) Effect of Organic Impurities on Strength of Mortar (ASTM C87)
- (i) Soundness of Aggregates by Sodium Sulfate (ASTM C88)

The test data on physical properties of the aggregates are presented in Table III. Table IV shows the sieve analysis results of the aggregates. Figure 1 shows sieve analysis envelope for regular concrete sand.

Foundry Sand

Greer et al. (3) reported in 1989 that only limited data is available on the physical characteristics of foundry by-products. Extensive tests were carried out to evaluate the physical properties of used foundry sands, at Center for By-Products Utilization, University of Wisconsin-Milwaukee.

Clean foundry sand from one source and used foundry sand from three different sources were selected and tested for their physical properties.

The test results are shown in Tables V and VI. The results show that there is a wide range of variability in physical properties of foundry wastes from one source to another. These variations are dependent on the type of equipment used in the foundry, the size and shape of casting made, the amount of core material per casting, type of additives and the number of times the sand was used. The type and amount of binder used in the molding sand also influences the physical properties to a great extent.

Test results for materials finer than 75 μm (No. 200) sieve in mineral aggregates by washing (ASTM C117) show that sand 4 has large amount of material finer than No. 200 sieve. This high volume is due to the large amount of binder present in sand; which were washed out during wet sieving. Unit weight of this sand, is lower than that of other foundry sand samples.

The sieve analysis results (ASTM C136) are shown in Table VI and the sieve analysis grading curves are plotted in Figures 2 - 5, along with ASTM Standard grading requirements for sand for concrete making materials. These figures exhibit that the foundry sands are not between ASTM limits. All the foundry sand samples are gap graded. About 90% of sand is retained on #50 and #100 sieves.

The saturated surface dry absorption values for sand 3 and sand 4 are relatively high. This is because of the presence of higher amount of binder in them, which absorbs more water. All the sands in this test pass the ASTM C40 test for organic impurities.

Some of the ASTM C33 tests were modified in order to apply to foundry sands.

As per ASTM C142, in order to determine the percentage of clay lumps and friable particles, sample selected should be retained on 1.18 μm (No. 16) sieve and final wet sieving is to be done on 850 μm (No. 20) sieve. As the particle size of foundry sand is much smaller than regular sand the above specifications do not apply to it (less than 2% of the sample is retained on No. 16 sieve). Hence, 150 μm (No. 100) sieve was selected as it represented a general sieve size on which 90% of the particles were retained, and wet sieving was carried out on 110 μm (No. 140) sieve.

Per ASTM C88 (test method for soundness of aggregate) (5), the test sample shall be such that it contains 100 g. of all materials retained on No. 4 (4.75mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 μm) and No. 50 (300 μm) sieves, and respectively passing through sieves 3/8" (0.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm) and No. 30 (600 μm). As shown foundry sands are gap graded. Hence, this test was modified. The sample used was 100 g. passing through No. 30 (600 μm) sieve and retained on No. 50 (300 μm) sieve. It was concluded that discarded foundry sands do not pass the test. The binders get washed away due to aggressive environment of saturated sodium sulfate solution. ASTM limits this loss to 12%. However, clean foundry sand passes the test. This indicates that the sand by itself is sound, but due the loss of binders and fines present an apparent failure.

Masonry Blocks

Mixture Proportioning

Total of five trial mixes were prepared to manufacture small size masonry blocks in laboratory. One control mix was made while other four mixes contained 35% replacement of regular sand with used as well as clean/new foundry sand. One out of the four mixes was prepared using clean/new foundry sand and other three mixes were prepared using wheelabrator sand, crushed core sand and excess system sand. All the mixes were proportioned to obtain strength of 1500 psi at 28-days. No additives or admixtures were added to the mix. The total water content in each mix was 5.3% of the total volume of the mix. The coarse aggregate used in masonry block mixes had the maximum size of 3/8", smaller than the regular coarse aggregate used in concrete. Details of the mixture proportioning is given in Table VII.

Manufacturing and Testing of Masonry Blocks

All of the mixes were prepared at Center for By-Products Utilization laboratories. The specimen size was scaled down from the regular size masonry blocks. The mold measured 4" x 2.5" x 1.81" with two rectangular 1.25" x 1.25" open cells. The gross area of the blocks is 10 in.² and the net area is 6.25 in.² and (62.5% of gross area). The details of the block is shown in Figure 6.

The aggregates and cement were mixed in dry state and then water was added to the mix. The mix was then compacted in block mold in three layers. The compaction was done using a pneumatic vibrating hammer. Soon after the compaction, the block was removed from the mold. The blocks were kept at room temperature and humidity for about 4 hours and then stored in the moist curing room maintained at 100% relative humidity till the time of test. Twelve small size blocks were prepared for each mix to determine compressive strength, bulk density and absorption. All the tests were carried out in accordance with ASTM C140. Three specimens were tested at three ages, 3-day, 7-day, and 28-day, for compressive strength.

Results and Discussions

Compressive Strength

The compressive strength data is shown in Table VIII. Results showed compressive strength increases with age. A plot of compressive strength vs. age is shown in Figure 7. All the mixes with used and clean/new foundry sand showed lower values of compressive strength than that of the control mix at all ages.

The mix 20-B2, mix with 35% replacement of regular sand with clean/new foundry sand showed the compressive strength lower by 16% at 3-day, 25% at 7-day, and 27% at 28-day age than the respective strength of control mix.

The mix 20-B3, mix with 35% replacement of regular sand with wheelabrator foundry sand showed lower values of strengths at all ages with respect to control mix and the mix with clean/new foundry sand. The compressive strength of mix 20-B3 lower by 27% at 3-day to 28% at 28-day with respect to respective values of control mix. However, the compressive strength values of mix 20-B3 is 13% lower at 3-day, 8% higher at 7-day and less than 1% lower at 28-day with respect to the values of mix 20-B2.

The mixes 20-B4 and 20-B5, having 35% replacement of regular sand with crushed core sand and excess system sand, showed poor results in comparison with control mix and mix with clean/new foundry sand. The 28-day compressive strength results of the mixes 20-B4 and 20-B5 are 26% and 47% lower than that for the mix 20-B2. The possible explanation to this type of behavior would be the high absorption capacity of the used foundry sands. As seen from Table V the percent absorption of excess system sand and core sand are 3.56% and 3.40%, respectively. In order to learn the behavior of each sand in mortar the water content in each mix was kept same. These high absorption capacity of sand would leave the mix comparatively dry and eventually hinder the strength gain of masonry blocks. The other possible reason for lower strength phenomenon would be the presence of high amount of binders. The micro binder particle stick to the sand particle and prevent it from strengthening the bond with cement paste. The high percent of binders were located during the tests ASTM C117 (Material finer than #200 sieve) and ASTM C142 (Clay lumps and friable particles). Results of these tests are reported in Table V.

Though, the mixes 20-B2 and 20-B3 showed the lower values of compressive strength than the control mix, at all ages, they reached the specified design strength at 28-day. In fact, 20-B2, mix with clean/new foundry sand, showed the compressive strength value higher by 2% than specified design strength. Similarly, 20-B3, mix with wheelabrator foundry sand showed 1.5% higher value of compressive strength than specified design strength.

Conclusions and Recommendations

1. Although foundry sand itself does not pass all the ASTM C33 requirements, the masonry blocks made with used foundry sand pass the ASTM requirements for strength, absorption and bulk density.
2. Compressive strength of the masonry blocks using clean/new foundry sand has reached the specified design strength at 28-day age.
3. Compressive strength of the mix 20-B3, with used wheelabrator sand also reached the specified design strength at 28-day.
4. The reduction in the strength of mixes 20-B4 and 20-B5 is attributed to presence of higher amount of binders and high absorption capacity of the sand.

5. The feasibility of using 35% replacement level of used foundry sand, in manufacturing masonry block has been established on the basis of short term testing.
6. It is not advisable to use higher percentage of replacement of regular sand with used foundry sand.
7. Some of the foundry sands with higher percent of binders may need to be processed before the use in manufacturing masonry blocks.
8. Quality and strength of masonry blocks can be improved with the use of additives and admixtures.
9. Foundries need to regulate the binder content in the foundry sands.
10. Quality of discarded foundry sands should be consistence, in order to develop market feasibility.
11. Sufficient long-term durability data needs to be generated to market the product.

References:

1. T.R. Naik, "Foundry Industry By-Products Utilization", Center for By-Products Utilization, UW-Milwaukee, p. 23, Feb. 1987.
2. "Solid Waste Disposal and Reuse in U.S.", Edited by Ishwar P. Murarka, Vol. 1 and 2, CRC Press, Boca Raton, Florida, 1987, Vol. 1, p. 187, Vol. 2, p. 160.
3. B.A. Greer, J.E. Vonderracek, R.K. Ham, and D.E. Oman, "The Nature and Characteristics of Foundry Waste and its Constructive Use: A Review of the Literature and Current Practice", a Report for the United Foundrymen of Wisconsin, Aug. 1987.
4. D.C. Edey, and W.P. Winter, "Introduction to Foundry Technology", Mc-Graw Hill Book Company, New York, P. 253, 1958.
5. American Foundrymen's Society, Inc., "Alternate Utilization of Foundry Waste Sand", a report to Illinois Department of Commerce and Community Affairs, p. 97, Aug. 1991.
6. Annual Book of ASTM Standards, American Society for Testing and Materials, Volume 04.01, 1990.
7. Annual Book of ASTM Standards, American Society for Testing and Materials, Volume 04.02, 1990.
8. Annual Book of ASTM Standards, American Society for Testing and Materials, Volume 04.05, 1990.

REP-167

Table I: Chemical Composition of Type I Portland Cement

Analyte	%
SiO ₂	20.25
Al ₂ O ₃	4.25
CaO	63.6
MgO	2.24
Fe ₂ O ₃	2.59
TiO ₂	0.27
K ₂ O	0.80
Na ₂ O	0.2
LOI	0.55

Table II: Physical Properties of Type I Portland Cement

No.	Test	Result	ASTM Specifications for Type I	
			Minimum	Maximum
(a)	Air content of mortar (%)	7.9	--	12
(b)	Fineness specific surface Air permeability test (m ² /kg)	391	280	--
(c)	Autoclave expansion (%) Specific gravity	-0.03	--	0.8
(d)	Compressive Strength (psi)	3.09	--	--
(e)	1 day	1254	--	--
	3 day	3512	1800	--
	7 day	4219	2800	--
	28 day	5375	--	--
(f)	Time of setting (min) (Vicat test) Initial set	155	45	--

Table III: Physical Properties of Fine and Coarse Aggregates (ASTM C33)

Gravel 1: Regular Concrete Pea Gravel (max. size 3/8")

Sand 1: Regular Concrete Sand

	As Received Moisture Content (%)	Unit Weight (lb/ft ³)	Bulk Specific Gravity	Bulk Specific Gravity (SSD)	Apparent Specific Gravity	SSD Absorption (%)	Percent Void (%)	Fineness Modulus	Material Finer than #200 Sieve (75µm) (%)	Clay Lumps & Friable Particles (%)	Organic Impurity for Fine Aggregate	Soundness of Aggregate Loss as (%)
ASTM	C566	C29	←----- C128 and C127 -----→				C29	C136	C117	C142	C40	C88
Gravel 1	0.31	109	2.64	2.67	2.74	0.8	34	N.A.	N.A.	0.40	N.A.	N.A.
Sand 1	0.39	115	2.43	2.47	2.52	1.0	25	3.57	1.35	0.22	Passes	10.0

Table IV: Sieve Analysis Results for Fine and Coarse Aggregates
(ASTM C136)

Gravel 1: Regular Concrete Pea Gravel (max. size 3/8")

Sand 1: Regular Concrete Sand

Sieve Size/ Opening Size	Percent Retained on each Sieve		Cumulative Percent Retained		Cumulative Percent Passing		Sand 1 Requirements ASTM C33 Cumulative Passing (%)	Gravel 1 Requirements for #8 ASTM C33 Cumulative Passing (%)
	Sand 1	Gravel 1	Sand 1	Gravel 1	Sand 1	Gravel 1		
3/4"	--	0.0	--	--	--	--	--	--
1/2"	--	0.0	--	--	--	--	--	100
3/8"	--	0.8	--	0.8	--	99.2	--	85 - 100
#4	0.12	86.4	0.1	87.2	99.9	12.8	95 - 100	10 - 30
#8	12.86	10.2	13.0	97.4	87.0	2.6	80 - 100	0 - 10
#16	13.63	0.6	26.6	98.0	73.4	2.0	50 - 85	0 - 5
#30	18.89	0.2	45.5	98.2	54.5	1.8	25 - 60	
#50	32.16	--	77.7	--	22.3	--	10 - 30	
#100	16.56	--	94.2	--	5.8	--	2 - 10	
Pan	5.67	1.0	99.9	99.2	0.1	0.8	--	
Total	99.89	99.2						

Table V: Physical Properties of Foundry Sand Samples (ASTM C33)

Sand 1: Clean/New Foundry Sand
 Sand 2: Wheelabrator Sand
 Sand 3: Crushed Core Sand
 Sand 4: Excess System Sand

	As Received Moisture Content (%)	Unit Weight (lb/ft ³)	Bulk Specific Gravity	Bulk Specific Gravity (SSD)	Apparent Specific Gravity	SSD Absorption (%)	Percent Void (%)	Fineness Modulus	Material Finer than #200 Sieve (75µm) (%)	Clay Lumps & Friable Particles (%)	Organic Impurity for Fine Aggregate	Ratio of Cube Compressive Strengths of Washed and Unwashed Sands (%)	Soundness of Aggregate Loss as (%)
ASTM	C566	C29	←----- C128 ----- →				C29	C136	C117	C142	C40	C87	C88
Sand 1	0.09	109	2.58	2.67	2.87	1.25	33	2.34	0.20	0.10	Passes	--	10.5
Sand 2	0.38	118	2.96	3.00	3.10	1.51	36	2.12	2.95	0.24	Passes	--	27.1
Sand 3	0.17	109	2.37	2.45	2.58	3.40	26	2.40	2.70	2.1	Passes	--	35.2
Sand 4	1.18	95	2.23	2.31	2.43	3.56	32	2.48	13.84	12.21	Passes	--	47.8

Table VI: Sieve Analysis Results of Foundry Sand Samples (ASTM C136)

Sand 1: Clean/New Foundry Sand
 Sand 2: Wheelabrator Sand
 Sand 3: Crushed Core Sand
 Sand 4: Excess System Sand

Sieve Size	Percent Retained on each Sieve				Cumulative Percent Retained				Cumulative Percent Passing				Required ASTM C33
	Sand 1	Sand 2	Sand 3	Sand 4	Sand 1	Sand 2	Sand 3	Sand 4	Sand 1	Sand 2	Sand 3	Sand 4	Cumulative Passing (%)
#4	0.0	0.0	0.3	1.2	0.0	0.0	0.3	1.2	100	100	99.7	98.8	95-100
#8	0.0	0.0	0.2	2.5	0.0	0.0	0.5	3.7	100	100	99.5	96.3	80-100
#16	0.0	0.3	0.2	1.0	0.0	0.3	0.7	4.7	100	99.7	99.3	95.3	50-85
#30	0.1	1.8	2.0	1.7	0.1	2.1	2.7	6.4	99.9	97.9	97.3	93.6	25-60
#50	40.5	22.6	38.9	36.7	40.6	24.7	41.6	43.1	59.4	75.3	58.4	56.9	10-30
#100	53.3	60.8	52.6	45.1	93.9	85.5	96.2	88.2	6.1	14.5	5.8	11.8	2-10
Pan	6.1	14.5	5.8	11.8	100	100	100	100	0.0	0.0	0.0	0.0	--
TOTAL	100	100	100	100									

Table VII: Mortar Mix Design and Test Data for Masonry Blocks

20-B1 Control Mix
 20-B2 Mix with 35% replacement of regular sand with Clean/New Foundry Sand
 20-B3 Mix with 35% replacement of regular sand with Wheelabrator Refuse Sand
 20-B4 Mix with 35% replacement of regular sand with Crushed Core Sand
 20-B5 Mix with 35% replacement of regular sand with Excess System Sand

Mix No.	20-B1	20-B2	20-B3	20-B4	20-B5
Specified Design Strength, psi	1500	1500	1500	1500	1500
Cement, lbs	360	360	360	360	360
Water, lbs	176	176	176	176	176
Sand SSD, lbs	1760	1144	1144	1144	1144
Foundry Sand, lbs	0	616	616	616	616
3/8" Aggregates, SSD, lbs	1152	1152	1152	1152	1152
Hardened Concrete Bulk Density, pcf	150	142	146	134	122
Water Absorption of Blocks (ASTM 140)	5.4%	5.5%	5.6%	7.2%	9.0%

Table VIII: Compressive Strength Test Data for Masonry Blocks (on the basis of gross area)

- 20-B1 Control Mix
- 20-B2 Mix with 35% replacement of regular sand with Badger Clean Sand
- 20-B3 Mix with 35% replacement of regular sand with Maynard Wheelabrator Refuse Sand
- 20-B4 Mix with 35% replacement of regular sand with Falk Crushed Core Sand
- 20-B5 Mix with 35% replacement of regular sand with Waupaca Excess System Sand

Mix No.	20-B1		20-B2		20-B3		20-B4		20-B5				
Test Age, Days	Compressive Strength, psi												
	Actual	Average	Actual	Average	Actual	Average	Actual	Average	Actual	Average			
3	1260	1220	1028	1020	811	887	478	480	380	390			
3													
3	1230		1132		1040		482		402				
	1180		908		792		476		388				
7	1850	1870	1400	1370	1500	1480	894	860	620	660			
7													
7	1900		1450		1500		834		702				
	1850		1250		1450		842		646				
28	1750	2120	1550	1530	1600	1520	1120	1130	830	800			
28													
28													

2150	1650	1500	1080	780
2450	1400	1450	1180	792

