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Experimental Work for Affecting the Workability, Compaction and Steel Depth on the Corrosion Phenomena

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Abstract: **Workability of the green concrete, compaction of concrete and cover depths play very important role to avoid corrosion of the steel reinforcement, also both the steel coating and steel diameters have its consideration effect to protect the steel reinforcement in structures. In this work twenty four specimens were cast, these were prisms 15 X 15 X 75 cm. Half of the specimens had steel reinforcements with diameter 14 mm and different covers 15 mm, 20mm and 30mm, while the second half had steel reinforcements the same cover 20 mm but with different steel diameters 10 mm, 12 mm and 14 mm, concretes for all specimens were mixed with different percentage of salt in mix water and water cement ratio (w/c= 0.35). Some specimens steel reinforcements were painted by primer (Sika Top Armatic – 110) and special additive (Sika viscocerte – 5400 salf concrete compaction S.C.C.) was added to improve the workability and compaction of the concrete mix.. The reinforcing steel had been connected to an electric circuit to accelerate corrosion process; the corrosion potential was being measured different on these specimens by (CSE) Half-Cell device.**

Keywords: **Concrete, Corrosion, Potential, Scaling.**

1. Introduction

There are many techniques, both physical and electrochemical, to delay initial or to slow existing corrosion activity by preventing the chloride ions reacting with the steel surface or increasing the time needed for the chloride ions to penetrate through the concrete cover. Similarly, there are various approaches to repair corrosion damage. While these measures generally don't stop corrosion from eventually initiating, they do increase the service life of reinforced concrete structure by slowing the corrosion process. The use of coated reinforcement is a widely used technique for corrosion prevention, two most common examples are epoxy-coated reinforcement and galvanized reinforcement. Fusion-bonded epoxy is intended to prevent corrosive elements from reaching the steel surface. Concern arises when the epoxy layer is damaged during transport or installation. If kept intact, epoxy coatings are effective for corrosion prevention (Vaca) [1].

In general, good quality concrete of appropriate mix proportions, compacting, and curing provides an excellent protective environment for steel. The physical protection is afforded by the cover concrete acting as a physical barrier to the access of aggressive. Chemical protection is provided by concrete's high alkalinity solution within the pore structure of cement paste matrix due to the presence of sodium and potassium oxides in the cement, as well as calcium hydroxide produced in the hydration reactions of cement components. The range of high pH values of typical concrete (12.5-13.5) is within the pH domain in which insoluble oxides of iron are thermodynamically stable [2-3].

To initiate corrosion, a threshold concentration of chloride (minimum concentration of chloride necessary to destroy the passive film) is required in excess of the amount immobilized by reaction with tricalcium aluminates in cement. It is generally believed that only freely dissolved chloride ions in the concrete pore water can be involved in the corrosion reactions. This threshold concentration of chloride ions to initiate corrosion is controversial, because it is dependent on so many factors including quality of concrete (W/C ratio, mixture proportions, type of cement), relative humidity and temperature of the concrete, the pH of the pore solution and sulfate content [4].

Galvanized reinforcement provides corrosion protection in two ways. The zinc-galvanized layer on the steel surface acts as a barrier to chlorides. Zinc also corrodes in a sacrificial manner in relation to steel reinforcement, protecting locations where the layer has been damaged or broken down. The zinc coating remains passive at pH values around 9.5, much lower than the threshold for unprotected steel. Galvanized reinforcement is most effective in situations with low or moderate chloride exposure (Yeomans) [5].Procedure for Paper

2. Experimental Work

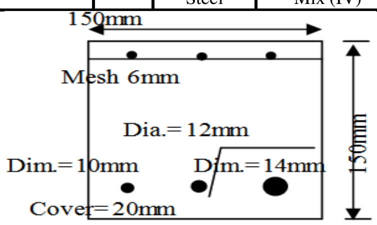
Twenty four prisms were under study from, the diameters sizes, the compaction of concrete, the salt amount in both mixing water and concrete components and the coating of the steel reinforcements. All specimens were cast with the same manner; the prisms were 15 X 15 X 75 cm. With steel reinforcements and the same mix design. One of these slabs was taken as a reference prisms without admixing the chloride amount.

3. Material and Mix Design

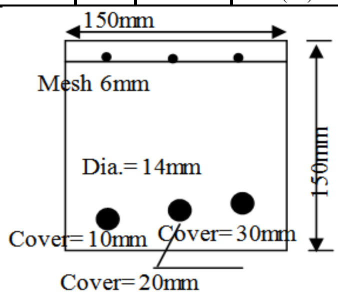
Table (1) Shown the details of the experimental program. The used materials were Ordinary Portland Cement and the combined aggregates were intended to be bad materials by admixing an amount of chloride 8.93 kg/m3 of concrete to the mix. The mix are proportions were 1:2:4 for cement, sand and gravel respectively by weight and water cement ratio 0.35. Four Mixes were prepared and the different mix, the steel reinforcing bars used were deformed high tensile steel with 10, 12 and 14 mm bars diameter. After prisms had been prepared in laboratory, they were placed vertically and sheltered. Then each twelve prisms were connected together in parallel to an adapter turnout 24 volts/4 Am to an AC Power supply.

Table 1.The details of specimens.

Spec.		NO	Steel Type	Material	Water salt
1	Eq.DD1	1	Normal Steel	Local material Mix (I)	0.4%
2	Eq.DD2	1	Normal Steel	Local material Mix (II)	0.6%
3-4	Eq.DD3	2	Normal Stee	S.C.C(0.15) Mix (III)	0.4%
5-6	Eq.DD6	2	Normal Stee	S.C.C(0.15) Mix (IV)	0.6%
7	Eq.DD7	1	Primer Steel	Local materia Mix (I)	0.4%
8	Eq.DD8	1	Primer Steel	Local material Mix (II)	0.6%
9-10	Eq.DD9	2	Normal Steel	S.C.C(0.15) Mix (III)	0.4%
11-12	Eq.DD12	2	Normal Steel	S.C.C(0.15) Mix (IV)	0.6%



Spec.		NO	Steel Type	Material	Water salt
1	Dif.ED1	1	Normal Steel	Local material Mix (I)	0.4%
2	Dif.ED2	1	Normal Steel	Local material Mix (II)	0.6%
3-4	Dif.ED3	2	Normal Steel	S.C.C(0.15) Mix (III)	0.4%
5-6	Dif.ED5	2	Normal Steel	S.C.C(0.15) Mix (IV)	0.6%
7	Dif.ED7	1	Primer Steel	Local material Mix (I)	0.4%
8	Dif.ED8	1	Primer Steel	Local material Mix (II)	0.6%
9-10	Dif.ED9	2	Normal Steel	S.C.C(0.15) Mix (III)	0.4%
11-12	Dif.ED12	2	Normal Steel	S.C.C(0.15) Mix (IV)	0.6%



Dif.ED : specimens with fixed cover for reinforcement
Eq.DD : specimens with different cover for reinforcement
S.C.C : Sika viscocerte – 5400
Primer : Sika Top Armatic – 110

The purpose of this cell is to achieve an accelerated corrosion process as shown in Figure (3). An electricity-conducting medium was made of 3 % sodium chloride solution, the prisms were sprayed daily with this .sodium solution each morning at time.

4. Test Results

All prisms which were prepared with reinforcement for both groups Dif.ED and EQDR didn't show any scaling after a long time and they had a good appearance comparing with other prisms systems. A crack propagated and cracks longitudinal parallel to the steel reinforcement for both groups Dif.ED and EQDR with widths not less than 0.3 mm and a medium corrosion rust appearance for systems, except reinforcement had no cracks appearance, this is due to the protection of the steel with painting.

The variation in most of the potentials with time for all prisms are presented from Fig. 1 to Fig. 4., for some prisms, the results show that The corrosion potentials (Ecorr.) were measured periodically to inspect the corrosion situation of the steel for both groups, the variations in the average potential values due to variation in weather conditions (degree humidity and temperature) with the effect of the dynamic corrosion cell, and

The potential values for prisms are ranging between -200, –500 mv. After that, the potential values exceeded the value of -350 mv high corrosion situation. That is clear from the tendency of the lines these indicate the potential values for both groups systems as shown Fig. 5-7.

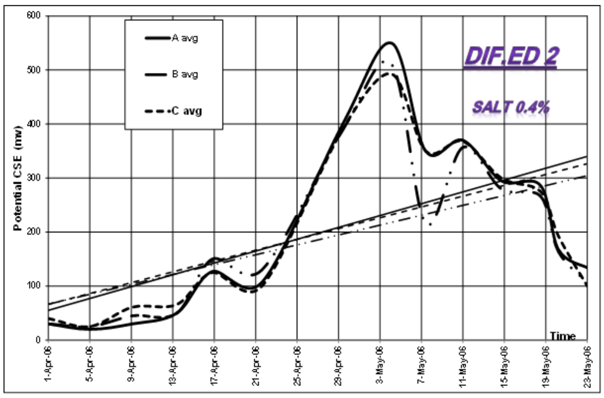


fig1(a)

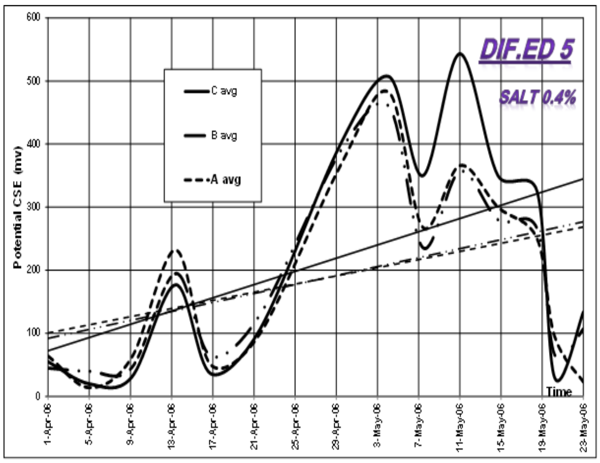


fig1(b)

Fig.1. Variation in potential values of the steel with time Dif.ED2 & Dif.ED5

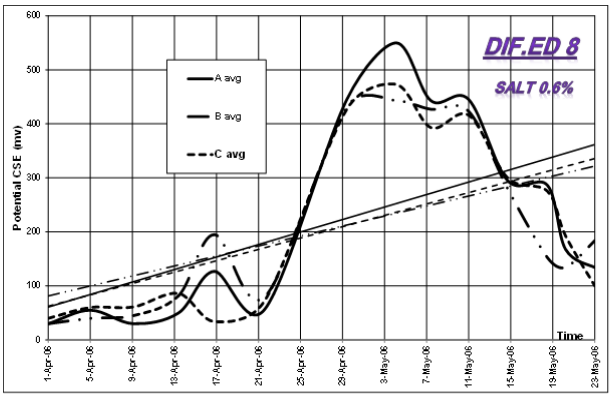


fig2(a)

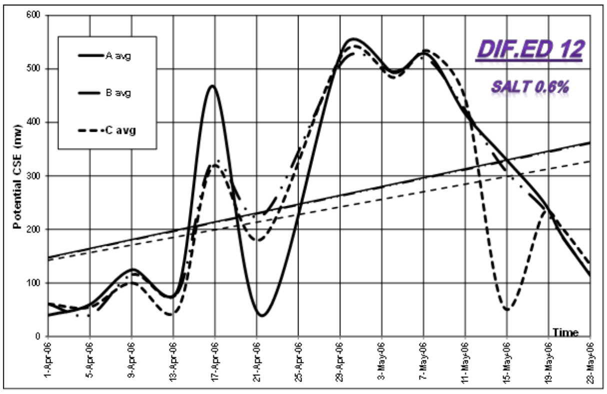


fig2(b)

Fig.2. Variation in potential values of the steel with time Dif.ED8 & Dif.ED12

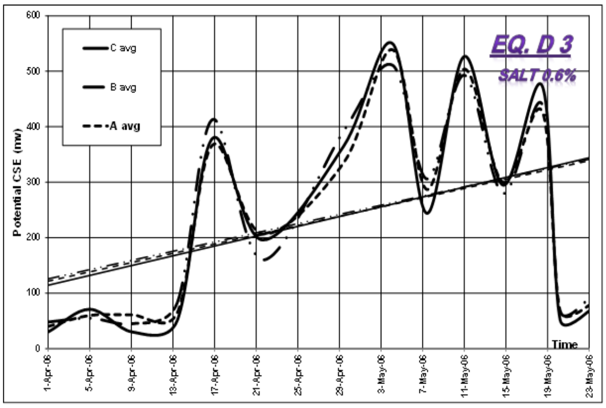


fig3(a)

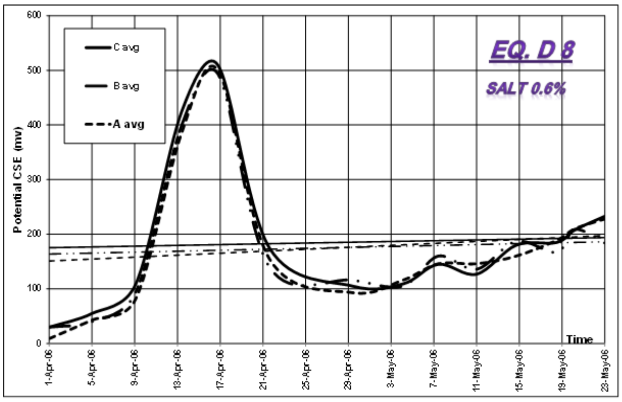


fig3(b)

Fig.3. Variation in potential values of the steel with time Eq.D3&Eq.D 8

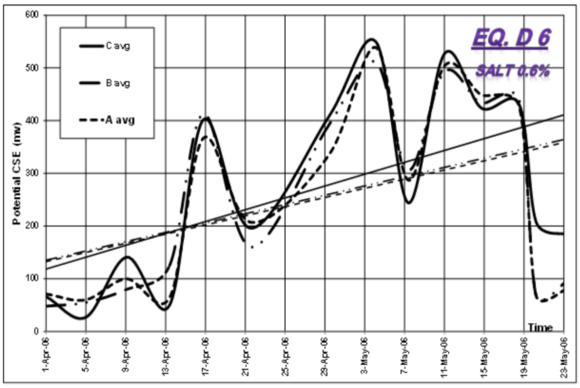


fig4(a)

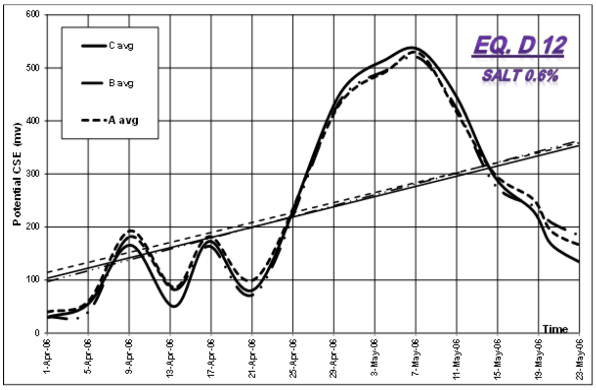


fig4(b)

Fig.4. Variation in potential values of the steel with time Eq.D 6&Eq.D 12

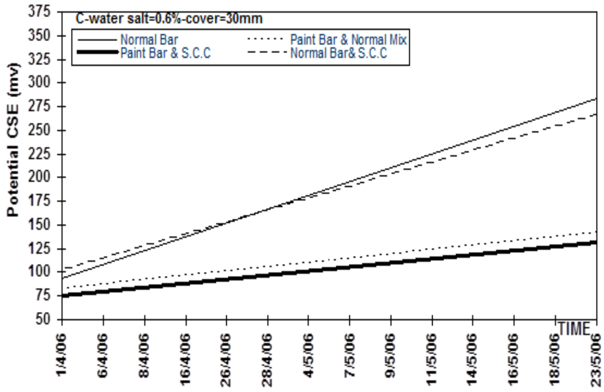


fig5(a)

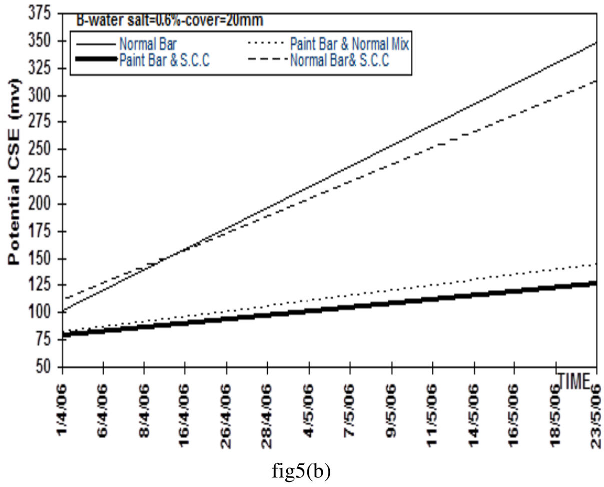


fig5(b)

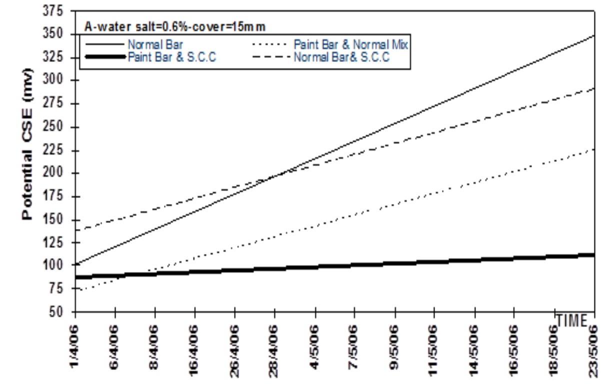


fig5(c)

Fig.5. Variation in potential average values of the steel - Salt 0.6% with time

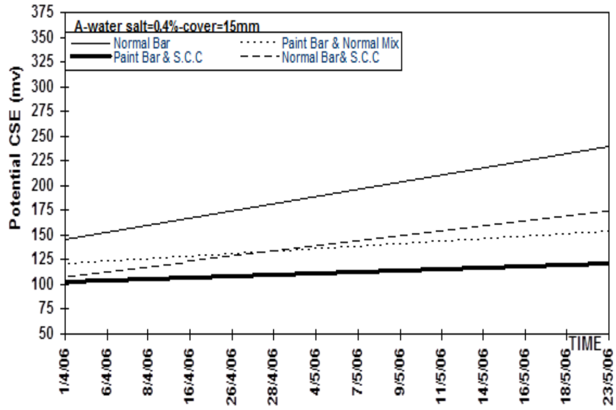


fig6(a)

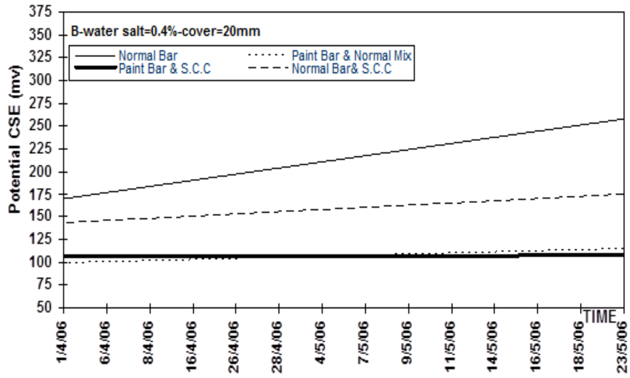


fig6(b)

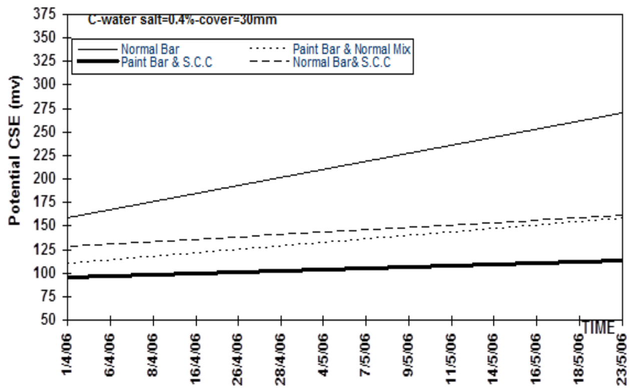


fig6(c)

Fig.6. Variation in potential average values of the steel -Salt 0.4% with time

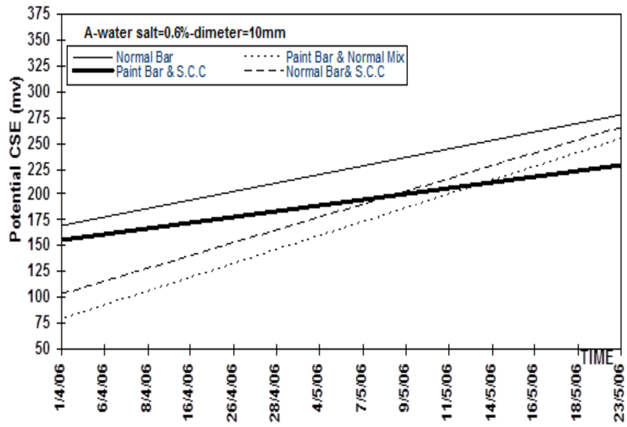


fig7(a)

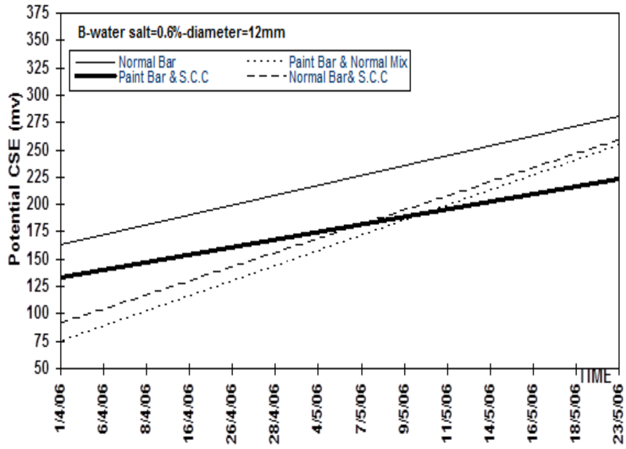


fig7(b)

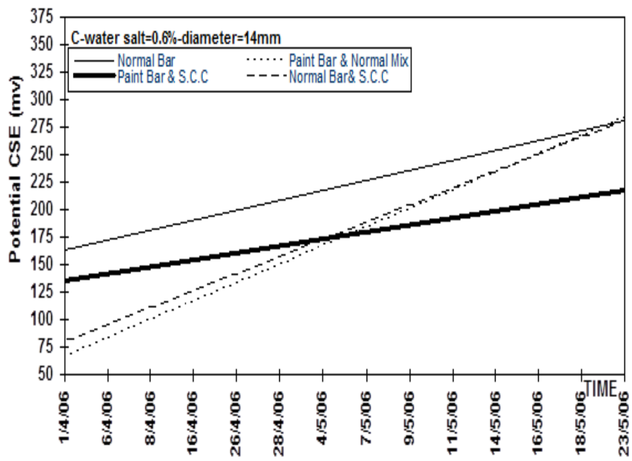


fig7(c)

Fig.7. Variation in potential average values of the steelcover 20mm-Salt 0.6% with time

5. Conclusion

The specimens normal compaction give high potential than concrete compacted S.C.C.(Self concrete compaction), above Figures illustrate that paint reinforcement bars with (Sika Top Armatic–110) and concrete mixes had S.C.C for different systems show after time low value of potential, measurements and the tendency lines slopes become lower than other bars without paint and without using S.C.C.. The bigger reinforcement bars give bigger surface arias subsequence low potentials value than the smallest bars which give higher potentials, also the bigger cover depths prevents the oxygen pent to the steel and gives low potentials than the smallest depths.

The specimens had 0.6 % salt in the mix design gives potentials higher than mixes had 0.4 % salt in the mix design. Specimens using S.C.C. gives no difference in potentials values comparing with the other prisms specimens using compaction machine and no using S.C.C.as shown in the following Table (2).

Table 2. The Details of The Experimental Program

Eq.D			Cover mm	Dif.ED			Ø mm		
30	20	15		14	12	10			
260	260	250	Normal Bar	250	250	260	Normal Bar	Potential (CSE) mv	0.4% Salt
125	140	150	Paint Bar Nor. Mix	130	160	240	Paint Bar Nor. Mix		
150	175	190	Nor. Bar S.C.C.	160	180	200	Nor. Bar S.C.C.		
110	110	110	Paint Bar S.C.C.	140	160	175	Paint Bar S.C.C.		
275	260	350	Normal Bar	260	280	280	Normal Bar	Potential (CSE) mv	0.6% Salt
125	125	150	Paint Bar Nor. Mix	260	240	250	Paint Bar Nor. Mix		
125	150	225	Nor. Bar S.C.C.	260	250	260	Nor. Bar S.C.C.		
115	115	115	Paint Bar S.C.C.	200	200	210	Paint Bar S.C.C.		

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